Nam Cheol Park
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Editors

Penile Augmentation

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Foreword

Penile augmentation is an important part of penile surgery, in which nomenclature is variable like augmentation penoplasty, enhancement phalloplasty, penile lengthening and augmentation surgery, penile lengthening and girth enhancement, and penile lengthening and thickening surgery.

Surgical techniques for penile augmentation have evolved continuously on the aspect of the medical demand and supply caused by men's desire to prefer larger penis as well as various social and cultural background. There are some controversies about the rationality because the surgical indication and standardization of surgical techniques have not yet been confirmed except the limited clinical situations including micropenis, concealed penis and acquired short penis due to injury or iatrogenic causes. Nevertheless, the clinical necessity of penile augmentation is beginning to be accepted like aesthetic surgery for women as the opposition theory.

Penile augmentation is mainly performed by girth enhancement and lengthening. Several new techniques and modifications for penile augmentation have been introduced in the world literatures. The techniques for penile girth enhancement are consist of synthetic material injection or implantation; tissue autograft using fat, dermis or fascia; heterogenous tissue graft; and tissue engineering. The techniques for penile lengthening are consist of skin reconstruction, liposuction, ligament release and glans advancement.

Finally, as a point not to be lazy, whether or not to receive the surgical procedure for penile augmentation or what surgical procedure to choose should be cautiously decided with preoperative counselling, psychological evaluation as well as neutralization of patient's overcharged expectation to surgical results. Patients with pyschologic problem like acute dysmorphic personality, dysmorphophobia, body dysmorphic disorder, locker room syndrome, body builder shower syndrome or sexual vanity syndrome should be obviously avoided to choose the surgical option.

This textbook will not only introduce recent advances in the field of penile augmentation surgery but also review the bright as well as the dark side of the surgery. Obviously scientific contents of this textbook will be a great guide in clinical practice for all who are involved or interested in the penile augmentation procedure.

Busan, South Korea

Nam Cheol Park, MD, PhD
Editor in Chief

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Part VI Pediatric Surgery

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Part I

General Perspective

Introduction

1

Nam Cheol Park

As an important area of penis surgeries, remarkable progress has been made with regard to the surgical technologies for penile augmentation operation in parallel with men's attention and desire to have bigger penis as well as corresponding medical demands. This surgery, however, has been referred with different surgical nomenclature given that, first, it is in its developmental stage; second, there are no established indications of the operation; and, third, no standardized surgical procedures were reported (Table 1.1). At this point, the operation is being limited from widespread applications due to, first, hesitation to the operation that has not been certified by relevant societies, e.g., ISSM; second, indiscriminate advertisements by some doctors; third, no critical necessity for penile augmentation; and, fourth, negative medical views on penile augmentation procedures due to varying rates of success for operations and serious complications, possibly owing to nonestablished surgical techniques. It is however warranted to pursue positive/active approaches and forward thinking as the operation is not only to fulfill the desires of men who want to have bigger penis but also to accomplish the primary objective for the correction of penile deformity.

Table 1.1 Synonym for penile augmentation

Penis general
Penile augmentation, augmentation penoplasty, augmentation phalloplasty
Penile lengthening and augmentation, augmentative phalloplasty
Penile enlargement procedure, penile bulking
Girth
Girth enhancement, girth augmentation
Length
Penile enhancement, enhancement phalloplasty
Length enhancement, penile lengthening
Glans
Glans augmentation

Abnormal Size of Penis and Their Etiological Factors

The penile size is determined based on the length from the skin of pubis top to the end of glans of the stretched penis. Out of two standard deviations below, the mean value is generally defined as either penile hypoplasia or micropenis. It would be also defined as small penis or short penis in which patients themselves or others consider it as small albeit the penile length is in the normal range (i.e., within two standard deviations of the mean size of penis). Wessells et al. [1] defined the penile hypoplasia if an erected penis is smaller than 13 cm of length and 2.5 cm of diameter. It was further addressed that the size of penis is positively correlated

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with their dimension of cavernous body. In contrast, Ponchietti et al. [2] investigated a total of 330 young men and reported that the average penile sizes were 9.0 cm in length with 10 cm of circumference of central penis and 12.5 cm on flaccid and stretched status, respectively. In Korean men, however, the average sizes of flaccid penis were 7.4 cm long, 2.8 cm of diameter, and 8.5 cm of circumference. When erected, they were 11.2 cm long, 4.1 cm of diameter, and 11.0 cm of circumference that are smaller than other reports from western countries [3, 4]. As above, despite multiple studies have reported regarding the sizes of penis, there is no generally accepted criterion. The occurrence rate of penile hypoplasia is relatively low, while micropenis can be observed more frequently in which patients accompany mental and psychological disorders such as dysmorphia, dysmorphophobia, body dysmorphic disorder, and locker room syndrome (also known as bodybuilder shower syndrome and sexual vanity syndrome). In particular, the dysmorphophobia is easily found in patients with delusional disorders, schizophrenia, depression, and obsessive-compulsive disorder. Such disorders may exacerbate symptoms in parallel with their penile size; thus, in terms of psychiatric perspective, it is understood to possess mental disorders for patients visiting for penile augmentation surgery even if their sizes are in normal range. In other words, medically speaking, small penis syndrome is not applicable for surgeries, but it could be necessary in terms of subjective beliefs of patients, at least. Therefore, treatment approaches for penile hypoplasia and micropenis should be basically different in regard to their cosmetic and functional aspects. Additionally, there are several other etiological factors responsible for abnormal sizes of penis: congenital factors (e.g., genetic factors, chromosome abnormality, endocrine dysfunctions, and exstrophy of the bladder) and acquired factors (e.g., endocrine dysfunctions, trauma, neoplasms, Peyronie's disease, and iatrogenic factors). Secondary impacts of abnormal sizes of penis include sexual dysfunction and urinary disorders in addition to psychological/cosmetic aspects.

Justifications for Penile Augmentation

According to a modern medical perspective, there are a number of different views of who would be applicable for penile augmentation, yet justifications for this operation might be reconsidered in terms of sociocultural, psychological, and medical aspects as follows.

Sociocultural Background

Across the ages and in all countries of the world, it has been long implied for men in human life and culture to have a bigger penis along with anti-impotence; it was expressed through artistic techniques such as literatures, arts, and sculptures or orally passed down in normal life. Such sociocultural background makes a strong desire to revise their size or shape of penis through surgical measures.

Psychological Aspect

The primary objective of penile augmentation procedure is to achieve psychological satisfaction by showing off their bigger penis rather than functional augmentation when erected. Therefore, patients with normal size of penis who want to undergo the operation may be considered on same level with female patients who want to have plastic surgeries to have a pretty face and skin or bigger breasts. Many patients visit urological clinics for penile augmentation to determine whether to have small penis or be in the category of penile hypoplasia thus experiencing psychological distress. Of these cases, many patients have distressed with their small penis more than several years which leads to further serious situation thereby making them impossible to go through not only their normal sex life but also normal family/social life. These mental statuses may be treated firstly via psychological evaluation and treatments, but penile augmentation procedure may give a chance to overcome mild mental disability, ultimately.

Development of Various Materials for Penile Augmentation (Table 1.2)

Materials utilized for penile augmentation include solid artificial materials, fluid artificial materials, and human tissues. In this, gradual progresses on materials, e.g., material, texture, tissue adherence and compliance, side effects, and penile augmentation effects, are implied. On early stage, animal products like bone and ivory were used. And widely utilized solid artificial materials include various shapes of metal, plastic, rubber, and solid silicon while fluid/soft artificial materials are oil analogue, e.g., paraffin, ointment base, Vaseline, collagen, hyaluronate gel (Perlane®, Juvederm®, Surederm®), pericardium (Lyoplant®), and fluid silicon [5–7]. Various synthetic fillers for penile augmentation will be introduced on chapter VII. Of human tissues, cartilage, bone, dermis, dermal fat, or dermal fat fascia might be utilized for penile augmentation [8, 9]. In several private sectors or by quack doctors, above applications have been illegally performed with little attention; in addition, serious complications (e.g., penile skin necrosis) have been reported owing to inappropriate materials for the operation which eventually bring up negative aspects of penile augmentation [6, 10–13]. In recent, however, surgical techniques utilizing human tissues which were medically certified, e.g., dermal fat graft, have been widely used for penile augmentation.

Table 1.2 Material for penile augmentation

Natural
Stone, wood, ivory, animal bone
Solid artificial
Metal, plastic, rubber, solid silicon
Soft artificial
Oil analogue (ointment base, paraffin, Vaseline), collagen, liquid silicon, synthetic filler
Autologous cell or tissue
Fat, dermis, fascia or combined, cartilage
Heterogeneous tissue
Pericardium

High Medical Demands in Penile Augmentation

Along with progress on techniques of penile augmentation, medical demands have been continuously increasing possibly due to promoting effects of mass media advertisements as well as bringing up of inherent desires of men. It was previously reported that there are a few countries, e.g., South Korea or Spain, widely performing penile augmentation operation [9, 12, 14]. It is expected that potential medical demands on this operation might be drastically increased in which ideal surgical techniques are established in parallel with publicity effects of mass media.

Selection and Indications of Penile Augmentation Patients

So far, there is no clear selection criterion for penile augmentation; in literatures, it is obvious to perform the surgery under strict and rigorous legal, ethical, and medical standards. Thus, in advance to determine the operation, proper evaluation and treatments of disorders should be preceded. To take an example, male hormone supplementation therapy should be considered for patients who have hypogonadism as a caudal disorder prior to penile augmentation.

When it comes to selection of eligible patients, a question might be posed if a patient determines to undergo penile augmentation procedure based on his subjective standards or judgment even though the size of his penis is in the normal range; medically speaking, it is unclear if he should be included in the range of indication of penile augmentation. Thus, thorough counseling must be provided for patients in advance prior to performing the operation in order to lower the expectation threshold and to explain exact surgical approaches and potential consequence of the surgery. The patients with dysmorphophobia who represent acute dysphoric personality should be excluded for the penile augmentation surgery. In particular, it is necessary to determine if dysmorphophobia is

involved with either cosmetic aspect, i.e., patients are more interested with the size of their penis when relaxed, or functional one, i.e., one's size of erected penis. Furthermore, psychiatric evaluation is required to be carefully performed by a psychiatrist. If an underlying disease was properly treated, psychiatric assessments were completed, and the operation is finalized, postoperative complications as well as surgical methods should be completely understood so that patients determine the operation. Dissatisfaction as well as legal issues might be raised in which above procedures are overlooked. Indications of penile augmentation include small penis due to preceding congenital disorders, e.g., hypogonadism in adults, or reduced size of penis owing to inherent causes, e.g., hypospadias, as well as acquired causes, e.g., penile paraffinoma or penile cancer surgeries, and penile trauma, thereby resulting in sexual disorders and potential mental disorders. The operation should not be performed in cases where patients exhibit excessive sexual vanity, severe obsessive-compulsive personality, apparent psychosis, promiscuous sex life, and unrevised penile deformity and are underage. Detailed information for the patient selection and counseling will be provided on chapter IV.

Types of Surgical Procedures and Their Progresses (Table 1.3)

The histological background of penile augmentation is not long, and most of the surgical techniques are modified and/or applied based on established methods in the field of penile surgery and plastic surgery. The penile augmentation can be classified into either augmentation of the girth of penis or extension of penis length. Neither of them is related with the size of erected penis. Yet they purse the external augmentation of relaxed penis, which was initially designed for revision of inherent penile deformity in infants, e.g., micropenis, hypospadias, and concealed penis [15]. Therefore, the primary objective of these surgical approaches is achieving psychological satisfaction through visual improvements, meaning morphological and cosmetic aspects, which is basically different with functional improvements of penile erection in penile prosthesis implantation. However, there are various surgical approaches currently developing to achieve both aspects, cosmetic and functional improvements.

Table 1.3 Surgical options for penile augmentation

I. Nonfunctional
Girth enhancement
Implantation of natural or artificial materials
Cell injection
Tissue graft
Allograft
Xenograft
Penile lengthening
Suprapubic lipectomy or liposuction, endoscopic or open
Ligament release, penopubic or fundiform
VY-plasty, Z-plasty, multiple Z-plasty
Corporal advancement
Corporal and crural separation
Penile disassembly and glans detachment
Penile traction therapy
Glans augmentation
Synthetic filler injection
Pediatric perspectives
Correction of micropenis, webbed penis, concealed penis, penoscrotal transposition
II. Functional
Tissue engineering
Penile tunica reconstruction in Peyronie's disease
Penile reconstruction in amputated penis
Penile prosthesis implantation

Penile Girth Enhancement

In order to enlarge the penile girth, soft/fluid materials as well as human tissues (e.g., cartilage, bone, fat, dermis, and dermal fat fascia) have been utilized [5, 6]. The most commonly performed technique for penile augmentation would be the implementation of solid silicon ring or silicon plates. This method has been implemented for penile augmentation as it is easy to perform and characterized with low costs, less side effects, and relatively high satisfaction albeit it has not been fully medically

validated in addition to side effects of implemented silicon.

Autologous tissue graft into adjacent tissues of cavernous body is one of the most widely performed surgeries for enhancement of penile girth; it was firstly performed by Neuber (1893) as well as Lexer (1910), approximately 100 years ago as fat graft [16]. However, it possesses limitations to be applicable as a universal method for penile augmentation due to accompanying side effects including infection, engraftment failure, fat atrophy, etc. In order to overcome these limitations of fat graft, Peer [17] proposed the dermis fat graft which aims to revise defects or malformation of soft tissues; in addition, Berson [18] and Bames [19] and Maliniac [20] further advanced dermal fat fascia graft and pedicled dermal fat fascia graft, respectively. In recent, microsurgical techniques were adopted in order to provide adequate blood supply for graft [19, 20]. In the mid-1980s, the penile augmentation using autologous dermofat graft was firstly introduced as fat injection into the penile dartos fascia, while the dermofat graft was successfully performed by Horton using the graft harvested from the lateral abdominal region [15]. Although there are a few studies reporting the glans augmentation utilizing artificial materials as well as surrounding tissue of penis and scrotum, it is still under in primitive situation [21]. As above, penile girth enhancement only considers cosmetic aspects, meaning making it look bigger without compromising functional properties, and orgasmic enhancement via increase in friction during intercourse.

Penile Length Enhancement

In order to augment penis, it can be projected forward or dropped downward by modifying shapes of adjacent tissues of penis as well as grafting artificial materials/human tissues, thereby making it longer or at least look longer. There are several attempts made to enhance the length of penis including skin remodeling of penopubic junction, removal of suprapubic fat, and amputation of abnormally developed fascia and ligaments. Surgical techniques include VY-plasty, Z-plasty, multiple Z-plasty, corporal advancement of cavernous body, cavernous body and crura release, fundiform ligament or suspensory ligament release, liposuction of suprapubic or infrapubic fat, plasty of webbed penis, and penile disassembly technique. Suprapubic liposuction or lipectomy might be applied in advance to skin remodeling of penopubic junction. Liposuction or lipectomy alone can be effective to extend about 2 cm especially for patients with severe abdominal obesity or concealed penis [22]. The VY-plasty, one of the most common techniques of dermoplasty, was firstly reported by Long [23] to treat a patient who had a small penis as he was bitten by a dog when young; after this, Roos and Lissoos [24] improved the method by revising the suspensory ligament through fixation of penis on the lateral skin flap of scrotum. Release technique of suspensory ligament was designed at first by Johnston [25] to separate cavernous body or penile crura from the pubic bone in order to extend the length of penis of a child patient with congenital micropenis accompanied with dorsal penile chordee or epispadias; in adults, it was firstly performed by Furlow [26] in 1993 to extend the length of penis in patients who underwent penile prosthesis. After this, a few studies reported the preventive effect of penile length reduction after skin remodeling or suspensory ligament release in patients with penile prosthesis implantation [27, 28]. It makes the length of penis to enhance approximately 2 cm by projecting cavernous body forward. Several techniques were conceived to prevent reduction of penile length after amputation of ligaments; of them, the method that sutures and attracts the gap between cavernous body and pelvis using 3-0 Vicryl through applying fat tissues from inner parts of both spermatic cords. In addition, polytetrafluoroethylene (Gore-Tex, W. L. Gore Associate, AZ), artificial testis, JES extender, or penis stretchers could be utilized [29, 30]. In a case with simultaneous suspensory ligament release and dermofat graft, utilization of penis stretchers may exacerbate swelling and pains in the penis. Thus, it is recommended to separately perform these surgical procedures. After several months later from the ligament release, dermofat graft may be performed as secondary procedure according to patient's request. To enhance the

size of penis, Perovic et al. [31, 32] proposed the penile disassembly technique. This technique completely separates glans penis, penile neurovascular bundle, and urethra from the distal cavernous body and then inserts harvested cartilage, muscle, or artificial materials into the space between glans penis and corporal tips. Although this technique is capable to enhance the penile length in response to the elasticity of neurovascular bundle, it is not widely performed due to high invasiveness. Further, it was reported that Montorsi et al. [7] applied multiple incisions on penile tunica albuginea in patients with serious fibrosis of cavernous body and followed by insertion of penile prosthesis, thereby achieving penile length enhancement.

Other than utilization of penile stretchers, nonsurgical methods for penile length enhancement include application of skin stretcher into the cavernous body and then gradually injecting normal saline solution. In this time, extensive enhancement may perforate penile tunica albuginea, so that requires cautions [30].

Functional Enhancement of Penis

Functional enhancement of penis might be considered as the most ideal penile augmentation. For this outcome, extension of tunica albuginea in cavernous body is obviously essential. Austoni et al. [33] firstly tried to achieve functional enhancement of penis through the corporoplasty using saphenous vein graft which is often applied in patients with Peyronie's disease. It was incised longitudinally both sides of tunica albuginea and inner side of reconstructed vein grafts was sealed toward the cavernous body, thereby enabling successful intercourse without functional disorders as well as enhancing the girth of penis. Despite of the invasiveness of the technique, i.e., corporoplasty, it is considered as an ideal technique for patients with penile hypoplasia or micropenis. In addition, reconstructive surgery of penile tunica albuginea using dermis or various artificial materials or the application of vacuum erection devices might be warranted to insert the bigger size in the penile prosthesis implantation [33–35].

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History and Cultural Perspective

2

Won Whe Kim

Introduction

Throughout history, east or west, the penis has defined masculinity and power. The penis is the very embodiment of a man's ego. But as man is competitive creature, almost every man seems to envy someone else's penis [1]. Large penis is a source of pride and satisfaction, and small or short penis is more humiliating than short stature or baldness. Usually, men want their penises to be bigger not to increase sexual satisfaction but to feel superior to others (Fig. 2.1).

Because the penis is a genital organ, discussion about this organ has been deemed taboo, or socially unacceptable in many cultures. It was generally seen only as a topic of lighthearted conversation and jokes. Length, girth, and function of the penis, however, have been important issues since ancient times. While most men are concerned about the length of their penis, about 90 % of women prefer a wide penis to a long one [2].

The average erect penis size is known to be between 13 and 15 cm in length and 9 cm in girth when flaccid, longest in Congolese and shortest in Korea [3, 4]. Durex survey also concludes that the erect penis of males in the Far East is about 2 cm shorter than Whites in length and girth. In fact, Japanese-manufactured condoms measure about 2.5 cm shorter than American made ones [5]. However, as men who think their size are below average are most likely unwilling to volunteer to be sized up, average sizes could be lower than reported.

The perception of having a large penis is often linked to higher self-esteem [6]. Many of those with average-sized penises believe that their penises are actually small. Man usually underestimates the size of his own penises compared to that of others as this organ does look smaller especially when he looks down at his penis.

There are two different types of human penises. The first type is called a "grower," and it expands and lengthens when erect. The second, the "shower," that looks large most of the time, but does not get much bigger during an erection. About 80 % of men have "growers" and 20 % have "showers." It should be noted that a man who has a small, flaccid penis might have a surprisingly large erection. Conversely, a penis that is large when flaccid might not get significantly larger when erected [7].

There are some in the male population who are afraid of their penis shrinking. This is because certain folklores have led to a type of hysteria called "penis panic" or "Koro," which means turtle's head in Malaysian words, which leads a man to believe that his genital organ is diminishing in size. Actual shrinking of the penis is rare, but "Koro" is not rare and often seen in Africa

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Fig. 2.1 Japanese painting of "penis competition." Late Edo era

and the Far East. Shrinkage of the penis can happen because of scar tissue formation in the penis from a medical condition called Peyronie's disease [8].

Does penis size matter to women? The length doesn't but the diameter does. More women prefer big penises, but not too big. In fact, the returns of a bigger penis start to decline after a flaccid length of 7.6 cm. However, many females admit that a small penis is less psychologically arousing during foreplay than an average or large penis. One survey done by *Playboy* magazine shows that among the women aged 25–50 who had borne at least one child, not one was found to be in favor of a small penis.

Size as a symbol of sexual demand is by no means limited to males. Large voluminous breasts are also preferred, as many women want to have surgical breast augmentation.

Evolution

The human penis is both longer and thicker than that of any other primate even when flaccid. Gorilla, orangutan, chimpanzee, and bonobo all have small penises that are almost invisible when flaccid [9]. About 4 million years ago, when man's hominid ancestors came down from the trees, their penises were probably about the size of other primates' (Fig. 2.2).

Fig. 2.2 Male gorilla's small genital

A male gorilla has a penis that is only 3–4 cm long when flaccid, with a testicle about half the size of human testicle which is extraordinarily small considering its body size. Unlike the human's, the gorilla's penis had no reason to be sexually selected to be big, as they can have female partners by force, not by attractiveness.

According to Darwin's sexual selection, both men and women have gone through the evolutionary process for hundreds and thousands of years to be attractive to his or her sexual partner [10]. When they became bipedal animals, their genitals, especially the male's penis, could easily be seen by others. Before human beings started to wear clothes about 170,000 years ago, the large, erect penis distinctively showed to females to be strategically advantageous, much like

Fig. 2.3 Monkey's advertisement of ovulation

advertisement of ovulation in other female mammals does the same toward the males (Fig. 2.3).

After humans started to walk on two feet, combined with loss of general body hairs, the penis began the process of "runaway selection," in that some traits such as prominent plumage or body ornamentation became so strongly preferred by females that they would mate more with those males possessing the strongest expression. In subsequent generations, male offspring were more likely to possess that physical trait [11].

Other scientists believe the reason that led to the evolution of a larger penis size in human beings is that it was advantageous in group sex during ancient times. And there are scores of other hypotheses as to why the penis is unnecessarily large in humans.

If human's penis is hidden into the body as it is in other animals, it would have been a completely different story. However, human beings began to live as members of a social society, and parents have to raise their offspring for at least 13 years for them to be able to use tools in order to obtain necessary proteins. As a consequence, a system of marriage, monogamous or polygamous, became mandatory for the sake of the child's survival, and humans as a result had to keep their sexual attractiveness.

Though the size of penis can be affected by biological needs through evolution, there are other factors to be considered, such as hereditary genes, of course. Those who lived in a hot weather environment, such as Africa, have dark skin, lose hairs, and flat nose. Contrarily, those who live in a cold weather environment, such as Northern Europe, have white skin, long nose, and a lot of hairs. This can be explained as natural selection.

Why is the penis smaller in the Far East? After living under the strong influence of Confucian and neo-Confucian ideology where women had very little right to choose their spouses, men probably were no longer concerned about selection. This as well as smaller figures in this part of the world could be one of the reasons, but there must be other factors to be searched further. Perhaps they followed the so-called Lamarckian evolution, in that one can pass on characteristics that one acquired during one's lifetime to one's offspring, and this modification does not go through genes but through culture [12].

Prehistoric Era

Human consistently wanted to leave their traces of living from ancient times. In many places in the world, we can find drawing, painting, and sculpture, and from that, we can see and understand the Stone Age men's ways of living. Their primary concern was on their food, hunting, and sex. Chauvet cave paintings in France and Maros cave paintings on the island of Sulawesi, Indonesia, were one of these kinds and known to be approximately 30,000–35,000 years old.

One of the petroglyphs of the neolithic era in Uljoo, Korea, distinctly shows the erect penis [13] (Fig. 2.4). There are also many old sculptures with erected penis. As the "Goddess of Fertility" was an idol in matriarchal society, the phallus became an idol in patriarchal society after humans came to understand that the man was needed in reproduction.

At Varna, Bulgaria, on the Black Sea Coast, old graves dating back to 4,000BC were found in 1968 showing the so-called golden penis, which was actually a penis sheath worn after death and it was actual size. However, real penis sheaths that were widely worn in many tribes of the tropical belt are rather exaggerated to be sometimes very big and long.

The famous cave painting showing a man having sex with a donkey may stress the power of the

Fig. 2.4 The petroglyphs of the neolithic era in Uljoo, Korea, showing distinctly erected penis

penis. Usually bestiality indicates a big, strong penis (Fig. 2.5).

Recently, an Ancient Korean civilization that existed over one millennium prior to the Yellow River civilization was discovered in Inner Mongolia region that is now in China. There were female figurines similar to the Willendorf Venus of Austria. Also, several jade engravings of sexual intercourse were found. In this civilization, female breasts, belly, and genitalia as well as male phalluses were exaggerated (Fig. 2.6) [14].

Greco-Roman

Since the introduction of Judeo-Christian culture in Europe, the Greco-Roman culture has never had good press in the West. However, we still can easily review them through arts, literatures, and inscriptions and to a lesser extent by archaeological remains such as erotic artifacts and architecture.

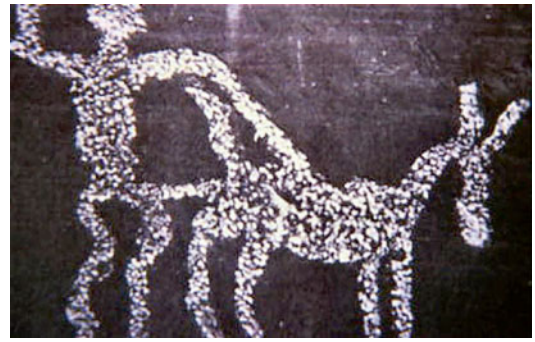

Fig. 2.5 Cave drawing in northern Italy. 1,300BC

Fig. 2.6 A relic with possible male symbol of the "Hong San Civilization." Now in Inner Mongolia, China

In Ancient Greece and Rome, sex was not at all tabooed or treated as a shameful subject. Greeks and Romans admired well-developed bodies of both males and females. Prostitution was legal, public, and widespread. Pornographic paintings were featured among the art collections in respectable, high-class households. Their societies were patriarchal, and masculinity was premised as a capacity for governing oneself and others of lower status, especially in sexual relations.

Fig. 2.7 Warren cup in British Museum showing pederasty. The older wearing a wreath is holding the passive younger youth with small penis

In Greece, pederasty, sexual relationship between a man and a boy, was not unusual. And some sculptures have small penis as an icon of boys' penises (Fig. 2.7). In ancient Greece, it was thought that big penises were for the barbarians or demons [15]. Of course, this idea changed as time passed.

Though Ancient Greeks thought a small penis was aesthetically superior to a bigger penis, they did have their own hang-ups about the sexual organ. Athens had a statue of Hermes with a big, erect penis in front of its main gate, which means Greeks had not only an open-minded attitude toward sex but also belief in the power and dignity of the erect penis. Their young men exercised naked in the gymnasium, and they stretched the prepuce over the glans and held it tight to the base of the penis with a ribbon. This means penile size and shape were of main concern to Athens. The erect penis also symbolized male power in ancient Greece.

During festival in Alexandria in 275 BC, there was a procession of hauling a gigantic 180-ft-long phallus through the city as part of the celebration of Dionysus, the Greek god of mystery, wine, and intoxication. People sang to it and recited poems. "Phallic identity" is the concept of a man seeking identity in his penis, which inevitably focuses on bigger as better [16].

Fig. 2.8 Bronze statue of Priapus in the Museo archeologico statale Gaio Cilnio Mecenate. First° century

Priapus, the Greek fertility god and protector of male genitalia, had a penis of oversized and permanent erection, from which the medical term "priapism" is derived (Fig. 2.8). Romans had a viewpoint that is slightly different from that of the Greeks [17]. Priapus became a very popular figure in Roman erotic art and Latin literature. The Greek way of linking the penis to strength and power was continued on in Roman culture. Depictions of exaggerated erections were everywhere in Rome, on paving stones, at the public bath, and on the walls of private houses.

The remains of Pompeii show many examples of erect phalluses in paintings and mosaics. Priapus was even more favored by Romans because of his large penis. He was in paintings, sculptures, and literature, especially poems. Over eighty poems about the fertility god still survive.

Among the ruins of Pompeii, there is a painting of a man wearing a short cloak and a red cap. His right hand holds a balance, one of whose pans is weighted with a bag of gold. With his left hand, he is raising the hem of his cloak to permit

Fig. 2.9 A man is fresco painting remained in Pompeii. His right hand holds a balance, one of whose pans is weighted with a bag of gold. With his left hand, is weighted with a bag of gold. With his left hand, he is raising the hem of his cloak to permit his penis to protrude and rest the balance's pan

his penis to protrude and rest on the balance's other pan. He seemed to be very proud to have big phallus (Fig. 2.9).

However, when it comes to literature, the Romans may have had a contrary view of penis size from culture. An uncircumcised and small penis was culturally seen as desirable in a man, whereas a bigger or circumcised penis was viewed as comical or grotesque, usually being found on "fertility gods, half-animal critters such as satyrs, ugly old men, and barbarians" [18].

Far East

Only China, Korea, and Japan are classified as Far Eastern countries. However, about one third of whole world population lives in this region and

Fig. 2.10 A clay figure with exaggerated penis. Third to fourth century, Shilla Dynasty, Ancient Korea

thus has been influenced by Confucianism, Buddhism, Taoism, and Shintoism.

China's first Empress, the mother of the Great Emperor, Qin Shi Huang (260–210 BC), was so lewd that she had an affair with a false eunuch, Roae, who is known to have the largest penis in Chinese history.

King Jijeung (437–514 AD) of the Shilla Dynasty of Korea had a big penis with a length of 45 cm. He had to send his subordinates to find a queen that fit him. They brought a lady who was 220 cm tall [19]. Koreans were very fond of big penises and believed the best one was thin with a long shaft and big glans. Clay figures from the Shilla Dynasty era also show many erotic figures with large penises (Fig. 2.10). In Korea, there is an old saying "Big nose, big penis," but the correlation between the size of men's penises to the size of their noses is a myth.

The Japanese erotic paintings have three characteristics: firstly, genital organs are very much exaggerated in size; secondly, pubic hairs are drawn one by one; and thirdly, models are always high-class people with gorgeous garments (Fig. 2.11). The first painting of this kind is the floor painting of the Horyuji temple from the eight century, which features a fairly large penis.

Fig. 2.11 Japanese erotic painting during the nineteenth century. Genitalia are very much exaggerated, especially in male penis. Most likely it was because of better incantation and to bring fortune through it. Female pubic hairs were drawn individually

Fig. 2.12 In Komaki, Japan, every year on March 15, Honen Matsuri takes place to make it the most popular time to visit. People carry about 3 hundred kilogram of wooden phallus

The Hounen Fertility Festival has been held in Komaki for many years. Though the ceremony starts early in the day every March 15th, the main event starts at 2 o'clock in the afternoon. A giant penis kept in Shinmei Shrine is carried to Tagata Jinja Shrine, where celebrators spin the phallus around in circles over their heads, threatening all around with 360° of mega penetration. People pray for a fruitful year and rub the sacred testes for good luck (Fig. 2.12). At Mara Kannon Shrine, one can see hundreds of artificial penises of various sizes, mostly large [20].

India

The Lingam is the symbol of a very special part of the Hindu god Shiva's body. In Hindu mythology, when Shiva is killed, the goddess Kali squats over his body, rips out and eats his organs, and then mounts his still erect penis to complete the cycle of creation. It's also worth noting that in most Hindu art and temples, his "lingam" is usually depicted without the rest of him, the disembodied member being worshiped all by itself (Fig. 2.13).

Fig. 2.13 Lingams

The Hindus were particularly appreciative of large penis. The Kama Sutra, the most famous piece of erotic literature and second bestselling book of all time after the Bible, divided men's penises into three categories according to their sizes. Hare size is 5–7 cm when erect, bull size is 10–15 cm, and horse size is 18–20 cm. Women's vaginas were also divided into deer, mare, and elephant, respectively, according to size [21]. The Kama Sutra advises on the ideal sexual mate by size of genitals, but also includes some dubious advice about using wasp stings for penis enlargement.

Ancient Egypt

Geb, the ancient Egyptian God of Creation, had an enormous penis that pointed toward the heavens and a grin of satisfaction on his face (Fig. 2.14).

Min was also an ancient Egyptian god whose cult originated in predynastic times. He was represented in many different forms, but was often shown in male human form with an erect penis. He was worshipped as a symbol of virility, and his symbol appears on the El Amrah Palette [22]. He was associated with the Egyptian longleaf lettuce, which was considered to be an aphrodisiac as it secreted a milky substance which was likened to semen.

Penis size is also alluded to in the Bible. In Ezekiel 23:20–21 of the Old Testament, it is written "Yet she multiplied her harlotries, remembering the days of her youth, when she played the harlot in the land of Egypt. She lusted after their paramours, whose flesh is like the flesh of donkeys and whose issue is like the issue of horses. Thus you longed for the lewdness of your youth, when the Egyptians handled your bosom because of the breasts of your youth." It may mean that "she" lusted after lovers with genitals as large as a donkey's and emissions like those of a horse.

Fig. 2.14 Man lying down below is the Geb, the god of the earth. Woman making an arch of the sky is the goddess Nut. Geb was the father of Osiris, Isis, Nepthys, and Seth

Medieval Europe

After Christianity became widespread in Europe, the body came to be seen as the enemy of one's soul, and sometimes self-flagellation, an act in which one whips himself, was common when one felt any sexual desire. Abstinence from sex was admired.

Sex itself was very much taboo. Nobody could ever dare to talk about penile augmentation. Only the "missionary position" for procreation was allowed. Woman on top or oral sex was punishable by 3 years penance. Oral and anal sex was considered sins. Homosexual acts could result even in the death penalty.

However, during the Renaissance period, a codpiece to cover the penis area appeared. This accessory can emphasize or exaggerate the penis and gives the appearance of an erect penis. Although there was no evidence to show that it was a means of showing male virility, the codpiece became a custom back then, and the bigger it was, the better. In Bronzino's Portrait of Lodovico Capponi, the codpiece peaks out from beneath the elegant young man's jacket (Fig. 2.15) [23]. Even today, codpieces are used by rock stars who wear it during concert performances.

Fig. 2.15 Agnolo Bronzino's portrait of Lodovico Capponi (1550–55). The codpiece peaks out from beneath the elegant young man's jacket

Arab

In medieval Arabic literature, longer penis was preferred, as described in an Arabian Nights tale called "Ali with the Large Member." As a witty satire of this fantasy, the ninth-century Afro-Arab author Al-Jahiz wrote: "If the length of the penis was a sign of honor, then the mule would belong to the Quraysh," the tribe to which Muhammad belonged and from which he descended [24].

Koteka (Penis Sheath)

The koteka or penis sheath is a phallocrypt or phallocarp traditionally worn by native male inhabitants of some tribes in New Guinea to cover their penis (Fig. 2.16). Similar kind of penis sheathes can be found in Africa, South America, and the Southwest Pacific Islands. Sheathes vary widely in size and shape. They are normally made from dried vegetable fibers, gourds, shells, bamboo, aluminum, cocoons, ivory, coconut, skin, leather, horn, etc. A penis sheath is usually held in place by a small loop of fiber attached to the base of the koteka and placed around the scrotum.

Fig. 2.16 The koteka or penis sheath worn by native male inhabitants of New Guinea to cover their penis

There is a secondary loop placed around the chest or abdomen and attached to the main body of the koteka [25]. It is not known why the koteka is used, but it draws attention to the penis and its reputed magical power. It seems to function as a constant symbol of an erection.

Men with Big Penises

Grigori Rasputin (1869–1916) was a very charismatic man who ingratiated himself with the Royal family of Russia. Women and men alike swooned at the sight of him. He was believed by some to be a psychic and faith healer having supernatural powers. He was also known to have a big penis of 32 cm. He once entertained as many as 20 women a night. One woman confessed that the first time she made love to him, her orgasm was so violent that she fainted. When Rasputin was murdered by a group of noblemen in 1916, some accounts say he was also sexually mutilated and his penis was severed. This big penis now rests in a jar at a Russian erotica museum in Saint Petersburg (Fig. 2.17) [26].

Fig. 2.17 Grigori Rasputin's genitalia now in a jar at a Russian Erotica Museum in Saint Petersburg

Fig. 2.18 Long penis

Porfirio Rubirosa, Dominican diplomat, made his mark as an international playboy, his jet-setting lifestyle, and his legendary sexual prowess with women. Among his spouses were two of the richest women in the world. According to his wives, his penis was 28 cm long. His conquests included many famous actresses, models, politicians, countesses, and queens. He died in a car accident in 1965 at the age of 56 [27].

Jonah Falcon, an American actor and writer, has been reported as having the world's largest penis at present with 24 cm in length when flaccid and 34 cm when erect. He has identified himself as bisexual and works as a gaming blog editor. He gained media attention after appearing in a 1999 HBO documentary (Fig. 2.18) [28].

The largest medically verified human penis on record is 34.3 cm long and 15.9 cm in circumference, documented in the early twentieth century by Dr. Dickinson. Other sources by various authors such as Alfred Kinsey, Masters and Johnson, etc., mention specimens ranged from 24 to 30 cm in length.

History of Penis Augmentation

The concept or idea of penis enlargement is one that has been around for centuries. There is no denying mankind's fascination with the idea of having a large penis, and this goes as far back as the cave drawings discovered in 440BC which showed male members of royalty with huge penises. The penis has always been as a symbol of manliness and pride.

Anthropologists have discovered that ancient cultures practiced penis enlargement. Everyone has heard the stereotype about Africans and their abnormally large penises. African cultures have worked hard over the centuries to make the penis as large as it can get. History shows that around 2,000 years ago, members of African tribes began the method of hanging weights from their genitals to obtain a desired size. Even though this method has been proved to reduce girth and even cause damage, some Africans practice this even nowadays.

The history of penis enlargement definitely sheds some light on why men throughout the years have tried so many different methods to try to enlarge their penises. Some methods have been deemed safe, while others border on the extreme and even dangerous. Some questionable practices have involved men manually stretching their penises by attaching weights to the tips and scrotum.

Followings are some of the examples men tried to enlarge their penises.

Traction or Stretch Method

According to Margaret Mead, Polynesian males stretch their penises with a woven device of plant fiber. The penis is inserted into one end of the tube while a weighted object is hung from the other end. Physiologically, this method may allow the relaxation of the suspensory ligament [29].

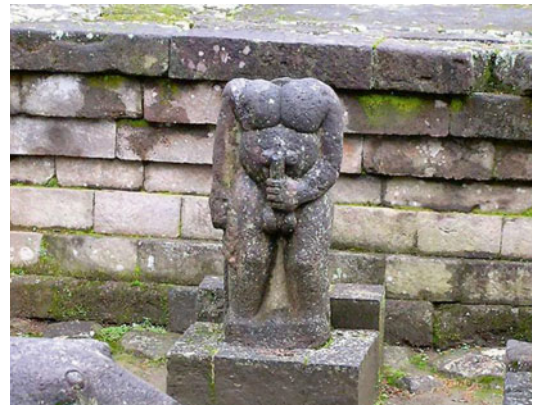

Fig. 2.19 This statue at Candi Sukuh, Central Java, Indonesia, might be to show penis enlargement

Peruvian Cholomecs and some African tribes used weights on their penis to increase their length. However, it didn't increase the girth. In fact, sometimes penis weights caused the penis to slim down like a noodle and seriously damaged the tissue, causing a man's tool to become unusable.

The Sadhus Holy Men of India and Papua Indians of New Guinea ritually employ penis stretching to lengths of up to 55 cm. As a weight, Sadhus men use some particular oval-shaped device starting as early as 6 years of age [26]. This may be like some of the extreme examples of traction of lip disks, ear disks, or neck rings to stretch these body parts to almost unbelievable size or length among some African tribal peoples and Amazonian indigenous tribes. Human body has amazing enlargement capability, and penis stretching to lengths of up to 55 cm is not surprising.

There are numerous other cultural examples of this type of penis elongation (Fig. 2.19).

Milking Method

This method advises shaking the penis up and down 25–50 times after the milking exercises to limber up and relax the connective tissue. This is known to be one of the secrets of Sudanese big penis [30]. In order to get optimal result, penis

Fig. 2.20 Milking method. Up-and-down movement as milking

must be only on semierect state as very soft or hard shafts are not in proper state to respond.

Arabic Jelq Method

Jelqing is the act of grasping one's semi-flaccid penis and slowly massaging it from base to tip repeatedly. In other words, it is a daily technique of stroking the penis to erection from base to top but stopping short of ejaculation and then starting the process again and again. Some people send their sons to athletic clubs (*mehbil*) to attend a practice course of this method (Fig. 2.20) [31].

This exercise began in the Middle East and was used by Arabic men to increase their penis sizes to about 50 cm. Whether this method is legitimate or not, jelqing is still very popular and is widely known by other names such as massaging, milking, or penis stretching. There are numerous other cultural examples of this type of penis elongation. This method increases not only the length but also the girth, and results were said to be visible within one month [32].

So-called penicure method has much in common with Jelq method. This method is to grasp the penis gently and stretch it half a dozen times daily. It involves forcing blood into the erectile body of the penis. Through repeated and sustained engorgement, the penis can be increased in both length and girth. This also can help relax the suspensory ligament over time (Fig. 2.21).

Snake Poison

In the sixteenth-century Brazil, the Topinama Indians allowed poisonous snakes to bite their penises to tremendously enlarge their penises. It is very painful, and the pain may last at least 6 months. However, the Topinama men viewed that pain as a worthy sacrifice for satisfying their women over and over [26].

Foreign Bodies

In Southeast Asia and Far East, some men tried to increase their penis size instantly by injecting Vaseline, paraffin, and other kinds of oils even by DIY (do-it-yourself) approach [5]. These were later replaced by silicone insertion. This method could also yield calamitous results such as infection, necrosis, and possibly amputation of the penis (Fig. 2.22) [33].

The Dayak tribe in Borneo mutilated their penises by forming holes and then sticking decorative items through them for their partner's pleasure. Sometimes, they inserted metal rods or bone in their penises in an effort to maintain a permanent erection [34].

Clamping

Another dangerous technique once practiced is clamping. This involves the use of a constricting device like a cock ring or even something as simple as a shoe string to clamp around the base of the penis while "edging" on an erect penis. This can cause problems especially if a metal cock ring is used. Cock rings are to be used only to maintain erection, not for penis enlargement.

Herbal Medicine

One of the many penis enlargement techniques is the use of herbal medicine. This was the only method used in Far East and other Asian countries in the past. Though herbal medicine is the main part of oriental medicine that is also called as Chinese medicine, phytotherapy is not the

Fig. 2.21 Showing Jelqing steps. (**a**) Ok grip. (**b**) Start. (**c**) Middle. (**d**) Finish

only way. Some drugs of animal sources and nutritional diet as well as acupuncture and combustion are included in oriental medicine as well (Fig. 2.23).

It was believed the size of the penis depends upon the "liver energy" and the function of penis depends upon the "kidney energy." The latter was considered more important in Asia as they concerned more on its function than the size. Since herbal and nutritional formulas are not drugs, effectiveness varied and sometimes unreliable among people.

There are too many to name but followings are included among what is supposed to be good to sexual medicine: ginseng, Ginkgo biloba, Rubus coreanus, Epimedium koreanum, garlic, etc. [35].

Sometimes, this method was used in conjunction with jelqing or other similar penis enlargement exercises. These herbs could increase the size and erection of the penis and boost sexual appetite.

Medical Procedures at Dawn

The first medical procedures to lengthen human penises were probably performed in the early twentieth century, but many were covert. Otto Lederer introduced the first commercially available penis pump in 1917. His invention of a simple vacuum pump to increase girth was a huge hit with men.

Kelley and Eraklis performed the first recorded penile augmentation in 1971 for the treatment of

Fig. 2.22 Complications of silicone injection. *Left* granuloma. *Right* infection. Cited from Ramesh Sasidaran et al. Low-grade liquid silicone injections as a penile enhancement procedure

Fig. 2.23 Maca root has been advertised as one of the herbs for penis enlargement

microphallus in the pediatric population [36]. Subsequently, the adult population began to show interest in the procedure for cosmetic and psychological reasons.

In the United States, both plastic surgeons and urologists perform penile enlargement procedures. However, such enlargements were not sanctioned procedure by American Urological Association.

Marketers of penis enlargement products exploit fears of inadequacy, but there is no consensus in the scientific community of any nonsurgical technique that permanently increases either the thickness or length of the erect penis that already falls into the normal range.

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Penis Anatomy

3

Kwangsung Park

Introduction

The penis is composed of paired corpora cavernosa and a corpus spongiosum, which are covered by fascia and skin [1]. The proximal ends of the corpora cavernosa are attached to the pubic bone. To understand penile anatomy, an understanding of penile embryology is needed. The differentiation of the male sex organ begins in the 7th week of gestation and is completed by weeks 16–17 [2]. Under the influence of androgen, the genital tubercle becomes the corpora cavernosa and glans penis, the endoderm tubularizes to form the penile urethra, and the ectoderm develops into the penile skin and prepuce [3].

The penis is an erectile organ; therefore, the size of the penis is dependent on the status of erection. The reported pendulous part of the penis in flaccid status is 7.6–13.0 cm in length and 8.5–10.5 cm in circumference, whereas in erect status is 12.7–17.7 cm in length and 11.3–13 cm in circumference [4]. Penile length is usually measured from the pubo-penile skin to the urethral meatus [5].

This section will present the gross anatomy of the penis, including the corpora cavernosa and tunica albuginea, glans penis and corpus spongiosum, the nerve and blood supply of the penis, and the superficial and deep fascias about the penis.

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Gross Structural Anatomy of the Penis

The penis is a cylindrical organ composed of two spongy, paired corpora cavernosa and a corpus spongiosum. The corpora cavernosa have a unique vascular bed consisting of trabecular sinusoids, which are enclosed by a tunica albuginea. The proximal end of the corpora cavernosa, the crus, is attached under the pubic arch, and the distal end is attached to the glans penis, which is an expansion of the corpus spongiosum [6–9] (Figs. 3.1 and 3.2).

The tunica albuginea is a bilayered structure which is composed of inner circumferential and outer longitudinal layers [10, 11]. The inner layer with the intracavernosal pillars supports and contains the cavernous tissue. The outer longitudinal bundles cover both the corpora cavernosa and the corpus spongiosum.

The corpus spongiosum is a spongy erectile tissue covered by a thin tunica layer; its proximal part is the bulb and its distal end forms the glans of the penis. There are few vascular communications between the corpora cavernosa and the corpus spongiosum. The tunica albuginea of the corpus spongiosum is thinner and lacks an outer layer and is absent in the glans [10].

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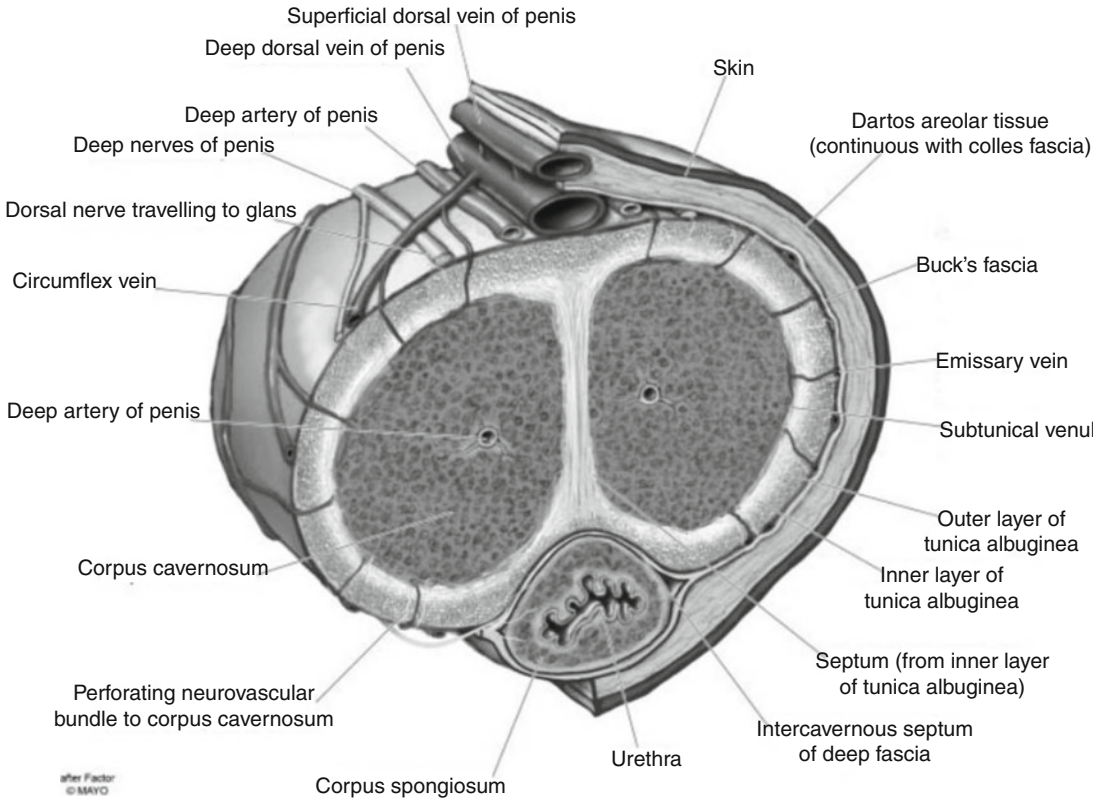

Fig. 3.1 Mid-shaft cross-section of the penis [8]

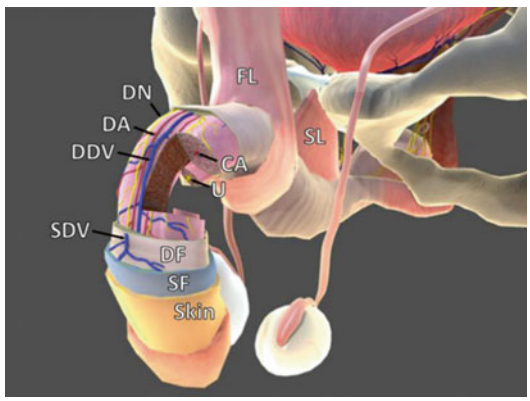

Fig. 3.2 Fascias and ligaments of the penis [9]. *CA* cavernosal artery, *DA* penile dorsal artery, *DDV* deep dorsal vein, *DF* deep fascia, *DN* penile dorsal nerve, *FL* fundiform ligament of penis, *SDV* superficial dorsal vein, *SF* superficial fascia, *SL* suspensory ligament of penis, *U* urethra

The glans penis is a continuous structure of the corpus spongiosum which caps the corpora cavernosa in a round shape [8]. The glans penis is attached to the corpora cavernosa through the corpora-glans ligament, which secures a firm connection between the glans penis and the distal end of the two corpora cavernosa [12, 13].

The penile skin is relatively loose, pliable, and hairless. Therefore, it is particularly moveable and expandable to accommodate an erection [8].

Vascular and Neural Anatomy of the Penis

The major blood supply of the penis is from the internal pudendal artery, which is a branch of the internal iliac artery [10]. It divides into three

branches: the cavernous artery, the dorsal artery, and the bulbourethral artery [6]. The cavernous artery supplies the corpora cavernosa, the dorsal artery supplies the glans penis, and the bulbourethral artery supplies the corpus spongiosum [14]. Accessory arteries may arise from the external iliac, obturator, vesical, and femoral arteries, which supply the corpus cavernosum [6]. The cavernosal artery, which is the main artery for erection and enters the corpus cavernosum in the penile hilum [6]. It runs centrally within the corpus cavernosum to supply the cavernous sinuses [8, 9] (Fig. 3.3).

The dorsal artery of the penis runs between the penile crus and the pubis and reaches the dorsal part of the corporal body [10]. It runs between the dorsal veins and the dorsal nerves, and goes to the glans penis [10]. These circumferential branches of the dorsal artery provide a dual blood supply to the urethral compartment with the bulbar arteries [8].

The venous drainage of the glans, the distal and mid shaft is mainly through the deep dorsal veins, and the proximal part is drained by the cavernous and the crural veins, which are merged to the periprostatic plexus and internal pudendal veins [15].

The neural innervation of the penis is divided into the autonomic (sympathetic and parasympathetic) and somatic (sensory and motor) neural systems [7]. The cavernous nerves, which affect neurovascular events during erection, are branches of the pelvic plexus, which travels the posterolateral part of the prostate and enters the crura of the corpus cavernosum and corpus spongiosum [7]. The dorsal nerve of the penis, which is the sensory nerve of the glans and penis, is a branch of the internal pudendal nerve. It runs along the dorsal aspect of the penis between Buck's fascia and the tunica albuginea and travels distally to the glans [16]. The pudendal nerve is a motor nerve to innervate the bulbocavernosus and ischiocavernosus muscles (Fig. 3.3).

The neurovascular bundle in the dorsal part of the corpus cavernosum is an important part during plastic surgery of the penis. It contains

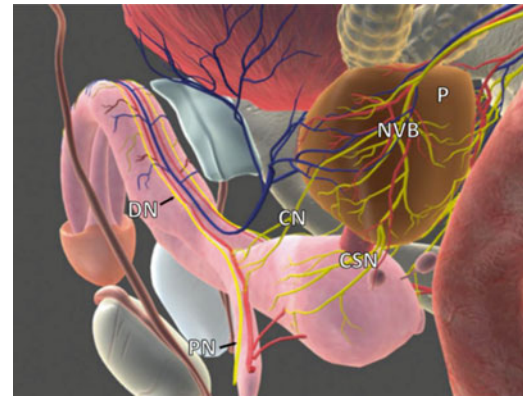

Fig. 3.3 Neurovascular systems of the penis [9]. *CN* cavernous nerve, *CSN* corpus spongiosum nerve, *DN* penile dorsal nerve, *NVB* neurovascular bundle, *P* prostate, *PN* pudendal nerve

dorsal arteries and dorsal veins and bundles of the dorsal nerve of the penis, which are located between the tunica albuginea and Buck's fascia [8].

Lymphatic drainage of the penile skin and prepuce runs toward the parasymphyseal plexus and drains to the superficial inguinal nodes. The anatomy of the lymphatic vessels in the penis is important to prevent postoperative refractory edema for penile lengthening surgery. Recent study using magnetic resonance lymphangiography has shown that there are 1–2 main lymphatic vessels on the root of the dorsal penis [17]. These lymphatic vessels course to the dorsal surface of the penis and finally merge to the inguinal lymph nodes [17, 18].

Superficial and Deep Fascias about the Penis

The penile shaft including the tunica albuginea is covered by four layers: the deep layer of the penile fascia, the tela subfascialis, the superficial layer of the penile fascia, and the penile skin [19, 20] (Fig. 3.4). The deep layer of the penile fascia is the Buck's fascia. The Buck's fascia has a dense connective tissue that covers both the cor-

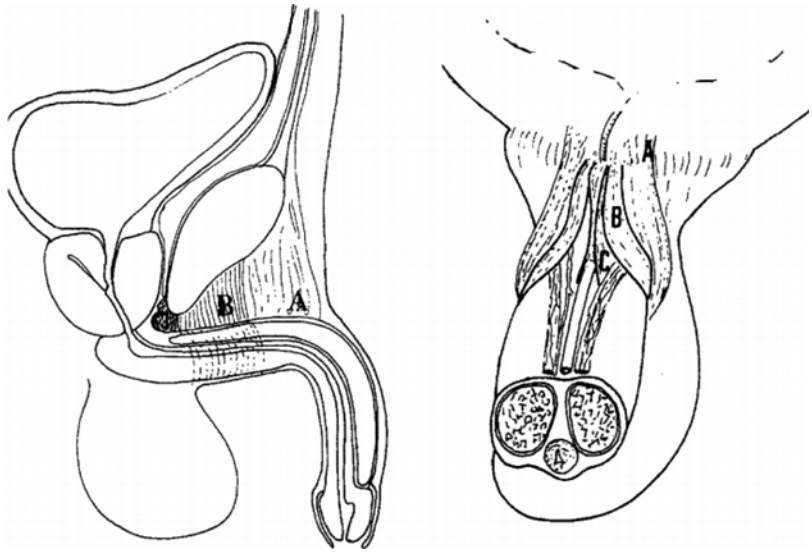

Fig. 3.4 Suspensory apparatus of the penis. Diagrammatic sagittal section representing the different distinct parts of the suspensory ligament of the penis. (a) Fundiform ligament, (b) suspensory ligament of the penis, (c) arcuate subpubic ligament. Diagrammatic anterior view of suspensory apparatus. (a) Fundiform ligament, (b) lateral bundle of suspensory ligament, (c) Median bundle of suspensory ligament [20]

pora cavernosa and the corpus spongiosum. It extends proximally to the perineal membrane and suspensory ligaments and distally to the coronal sulcus [19]. Buck's fascia encloses the dorsal arteries, dorsal nerves, and deep dorsal veins. The tela subfascialis is a very thin connective tissue layer that is located beneath the dartos fascia and Colles' fascia [19]. The superficial fascia of the penis or dartos fascia continues to the Scarpa's fascia of the lower abdominal wall. It contains the superficial penile arteries, superficial dorsal veins, and vessels that supply the skin.

The root of the penis is supported by two important ligaments: the fundiform ligament and the suspensory ligament [1]. The fundiform ligament is superficial to the suspensory ligament. It is a loose fibrous layer that arises from the linea alba of the lower abdominal wall to extend laterally on either side of the base of the penis and to meet the septum of the scrotum [20].

The suspensory ligament of the penis consists of the suspensory ligament proper and the arcuate subpubic ligament, which attaches the tunica albuginea to the symphysis pubis [20]. It maintains the base of the penis to support the mobile portion of the penis during erection.

The Muscles Related to the Corporal Bodies

The ischiocavernosus and the bulbospongiosus muscles play a role in both erection and the ejaculation mechanism [10]. The ischiocavernosus muscle covers the crural part of the penis. It is attached to the medial part of the ischial tuberosity and related ischial ramus and forces blood from the crus to the body of the erect penis [10]. The bulbospongiosus muscle consists of two symmetrical parts united by a median fibrous raphe [10]. It covers each side of the bulb of the penis, which facilitates compression of the deep dorsal vein and erectile tissue of the bulb [1, 10, 11].

Conclusion

An understanding of penile anatomy is crucial to preserve sexual function during penile reconstructive surgery including penile augmentation. Knowledge of functional penile anatomy enables the surgeon to properly design the method of reconstruction and to provide the highest level of care to the patient.

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Patient Selection and Counseling

4

Ju Tae Seo and Jin Ho Choe

Introduction

The purpose of this chapter is to introduce the measurements of penile dimension, summarize the available literature on penile size, discuss conditions that contribute to penile shortening, and highlight the indications of penile augmentation surgery. A physical examination should involve an assessment of body habitus, detailed genital examination (significant suprapubic fat pad, testis, and secondary sexual characteristics) with careful exclusion of genuine penile anomalies. Careful measurements of flaccid length, stretched length, erect length, flaccid circumference, and erect circumference are essential. The definition of a normal penile size has become of increasing interest to perform correct diagnostic assessment and therapeutic choice in patients with concerns regarding penile adequacy. By definition, micropenis is "a normally formed penis that is at least 2.5. S.D. below the mean in size." Penile shortening is a phenomenon that is associated with certain medical and surgical conditions, including penile cancer, penile trauma, excessive skin loss, prostate cancer treatment modalities, buried penis, Peyronie's disease, and congenital anomalies (epispadias, hypospadias and intersex disorders).

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Assessment

During the patients' initial consultation, a detailed medical and sexual history should be obtained. The clinician must determine whether the main concern relates to flaccid or erect length and whether girth is a significant concern. The motivation (internal or external) and expectations of the consultation must be understood. A full medical, psychosexual, and psychiatric history should be undertaken. The most common scenario in patients with penile dysmorphic disorder consists of anxiety and embarrassment arising from changing in front of others, that is, the "locker room syndrome." The "locker room syndrome" or "small penis syndrome" is defined as an anxiety and found in men with a normal-sized penis, but who are anxious about the size of the penis, in contrast to men who have a truly small penis (micropenis) [1]. It might have its origin in childhood, when the young boy observes the larger phallus of an elder sibling or a friend, or even of his father. In one study.

A physical examination should involve an assessment of body habitus and detailed genital examination with careful exclusion of genuine penile anomalies such as hypospadias, epispadias, and Peyronie's disease. Testis and secondary sexual characteristics also must be inspected to exclude an endocrine abnormality. The presence of a significant suprapubic fat pad should be noted. Careful measurements of flaccid length, stretched length, and flaccid circumference

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(girth) are essential. If the erect size, particularly of circumference, is an issue, then measurements after intracavernosal alprostadil (prostaglandin E1) are also helpful (or ask the patient for a digital image of the erect penis). As endocrine abnormalities can cause true micropenis, a general assessment of the secondary sexual characteristics is valuable. The measurement of penile dimensions is a basic requirement for evaluating the success rates of penile augmentation surgery. Specifics of measurement of penile size are also important in comparing data in different papers. Although there is no standard technique for measuring penile size, there appears to be a consensus among researchers that penile length should be measured on the dorsum of the penis beginning from the pubopenile junction to the tip of the glans using a ruler with millimeter markings, with the subjects standing up (Fig. 4.1) [2]. This measurement applies to the flaccid, stretched, and erect states. In addition, measurements of penile circumference should be obtained from the middle of the penile shaft, in all three states. For the purpose of clarity of nomenclature, a flaccid penis is one that is unstimulated or not aroused and would be seen when the man is in the normal anatomical position. Flaccid stretched is when the flaccid penis is pulled to its maximal – but not painful – distance. Lastly an erect penis is one that is maximally stimulated, either through visual, tactile, or pharmaceutical manipulation.

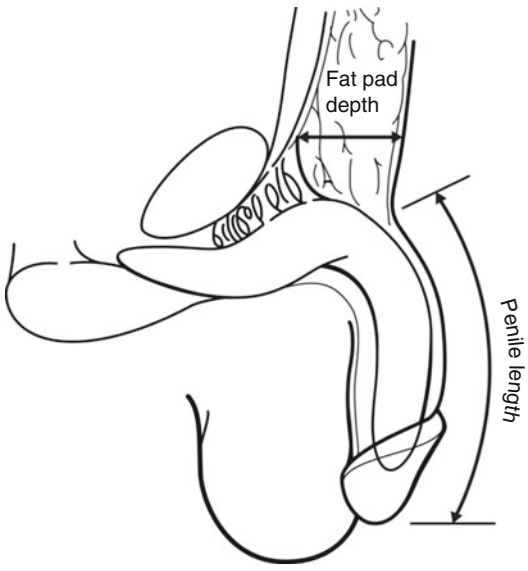

Fig. 4.1 Flaccid penile length from pubopenile skin to meatus and fat pad depth from pubic bone to pubopenile skin

Its flaccid length is controlled by the contractile state of the erectile smooth muscle and varies considerably, depending on emotion and outside temperature. Adequate precautions (adopting same method of measurement, using similar types of ruler or tapes, maintaining comfortable room temperature) should be taken to ensure uniformity of measurement. After genital exposure, immediate measurements are recommendable in order to minimize the effect of external temperature. Additionally, adequate privacy should be ensured. The stretched penile length is a good guide to the potential erect length. However, practically, there can be two important difficulties in measurements of stretched penile length: determination of the penopubic junction and the upper limit of force applied to during measurement.

No patient seeking enlargement of a normal penis should be operated upon without a psychiatric assessment. Therefore, after an initial consultation, patients with a possible diagnosis of penile dysmorphic disorder should be encouraged to seek psychiatric or psychosexual counseling and discouraged from surgery.

"Normal" or Average Penile Size

Many scientific research papers have tried to answer the question to which many men want an answer – what is the average penis size?

Flaccid penile length is just under 4 cm at birth and changes very little until puberty, when there is marked growth [1]. There is marked variation within individuals, with heat and exercise, as well as anxiety, all contributing to the variation. The various studies describing normal penile dimensions are shown in Table 4.1 [2–27] (Table 4.1). These studies measured various aspects of penile size, including flaccid length, stretched length, erect length, flaccid circumference, and erect circumference. The variability of

Table 4.1 A summary of previous reports on normal penile dimensions

First author	Publication year	Country	Number of subjects	Age in years (range)	Penile length (cm)			Penile circumference (cm)	
					Flaccid	Stretched	Erect	Flaccid	Erect
Loeb [3]	1899	Germany	50	17–35	9.41	NA	NA	NA	NA
Schonfeld [4]	1942	USA	54	20–25	NA	13.02	NA	8.55	NA
Kinsey [5]	1948	USA	2770	20–59	9.7	NA	15.5	NA	NA
Ajmani [6]	1985	Nigeria	320	17–23	8.16	NA	NA	8.83	NA
Bondi [7]	1992	France	905	17–91	10.7	16.74	NA	NA	NA
Da Ros [8]	1994	Brazil	150	NA	NA	NA	14.5	NA	NA
Richters [9]	1995	Australia	156	18–55	NA	NA	15.99	NA	13.47 (base)
Wessells [2]	1996	USA	80	21–82	8.85	12.45	12.89	9.71 (midshaft)	12.30 (midshaft)
Smith [10]	1998	Australia	184	NA	NA	NA	15.71	NA	13.19 (base)
Bogaert [11]	1999	USA	935[a]	NA	10.41	NA	16.40	9.75	12.57
Bogaert [11]	1999	USA	4187[b]	NA	9.83	NA	15.60	9.40	12.19
Chen [12]	2000	Israel	55	21–78	8.3	12.5	13.6	NA	NA
Ponchietti [13]	2000	Italy	3300	17–19	9.0	12.5	NA	10.0 (midshaft)	NA
Schneider [14]	2001	Germany	111	18–19	8.6	NA	14.48	NA	NA
Schneider [14]	2001	Germany	32	40–68	9.22	NA	14.18	NA	NA
Mondaini [15]	2002	Italy	67	16–55	9.0	12.5	NA	NA	NA
Sengezer [16]	2002	Turkey	200	20–22	6.80	8.98	12.7	NA	NA
Shah [17]	2002	England (UK)	104	17–84	NA	13	NA	NA	NA
Spyropoulos [18]	2002	Greece	52	19–38	NA	12.18	NA	8.68 (base)	NA
Son [19]	2003	Korea	123	19–27	6.9	9.6	NA	8.5 (midshaft)	NA
Awwad [20]	2005	Jordan	271	17–83	9.3	13.5	NA	8.98 (midshaft)	NA
Mehraban [21]	2007	Iran	1500	20–40	NA	11.58	NA	8.66 (midshaft)	NA
Promodu [22]	2007	India	301	18–60	8.21	10.88	13.01	9.14 (midshaft)	11.46 (midshaft)
Kamel [23]	2009	Egypt	1047	17–72	8.9	12.9	NA	NA	NA
Aslan [24]	2010	Turkey	1132	19–30	9.3	13.7	NA	NA	NA
Khan [25]	2011	Scotland (UK)	609	16–90	8.7	14.3	NA	NA	NA
Söylemez [26]	2012	Turkey	2276	18–39	8.95	13.98	NA	8.89 (midshaft)	NA
Herbenick [27]	2014	USA	1661	18–39	NA	NA	14.15	NA	12.23 (base)
Average			15849	16–91	8.91	12.61	14.52	9.09	12.49

[a]Homosexual
[b]Heterosexual

some of the values recorded inevitably reflects the different populations studied and differing techniques of measurement. Here are the representative reports on penile size. The first reported study was conducted by Loeb in 1899. He measured the penis only in the flaccid state and found the average size to be 9.41 cm. It was not clearly stated how measurements were made [3]. In 1942, Schonfeld and Bebe looked at the normal variability of penile size, both length and circumference of the penis from birth to maturity. With respect to penile length, measurements were recorded only in the stretched state; however, they looked at penile circumference in both the erect and flaccid conditions. They found that the average stretched length was approximately 13.1 cm. Additionally they found the average circumference of the flaccid penis to be 8.5 cm and the average circumference of the erect penis to be 15.8 cm. They also noted that the length of the stretched penis approximated the length of the erect penis, while the flaccid circumference was a poor indicator of erect circumference [4]. In 1948, Kinsey measured subjects in both the flaccid and the stretched flaccid states. He found that the average flaccid length was 9.7 cm and the average stretched length was 16.74 cm [5]. In 1992, Bondil et al. studied 905 men (age of 17–91 years) to examine the extensibility of the penis. Penile length was recorded in three conditions: flaccid, maximal flaccid stretched, and flaccid after stretch. The maximal flaccid stretched length was achieved by pulling on the glans three times, allowing for "tissue viscoelasticity." After the penis was measured at its maximal flaccid stretched length, it was then remeasured in its flaccid length, which they defined as "flaccid after stretch." Lengths were found to be 10.7 and 16.74 cm in the flaccid and stretched states, respectively. They concluded that extensibility decreases with age [7]. In 1992, da Ros and colleagues published the first series examining the length of the erect penis. The study was conducted in a group of Caucasian men who were interested in penile lengthening. 150 men were enrolled in the study and were given an intracavernosal injection of papaverine and prostaglandin to achieve erection, after which measurements were obtained. Measurements of circumference were taken both proximally and distally. The authors found that the average erect length in their 150 subjects was 14.5 cm, proximal circumference 11.92 cm, and distal circumference 11.05 cm. After data were collected, and information was shared about the "normal" ranges of penile length, men were no longer interested in penile lengthening surgery [8]. In 1999, Bogaert and Hershberger investigated the relationship between sexual orientation and penile size. In their study, there were two cohorts of 935 homosexual men and 4,187 heterosexual men with a mean age of 30 in both groups. Self-reported penile length was performed in five measurements: estimated erect size, flaccid penile length, erect penile length, flaccid circumference, and erect circumference. The authors reported that there was a significant difference in both penile length and circumference in this self-reported mailed questionnaire population, with homosexuals having the greater length and circumference. The authors suggested that this might reflect greater in utero exposure to androgens, but again it is an area that needs further research. The validity of self-reported measurements needs to be considered when evaluating these data [11]. Wessells et al. published their data regarding penile length and indications for penile augmentation. They examined penile lengths in 80 men with a mean age of 54 years. Measurements were taken in the flaccid, stretched, and erect conditions. Measurements of the erect penis were obtained by injections with prostaglandin E1, and in some cases of incomplete erection, phentolamine/papaverine was added to achieve full erection. The average flaccid length was 8.85 cm, average stretched length 12.45 cm, and the average erect length 12.89 cm. Circumference was recorded midshaft in the flaccid condition and erect conditions at 9.71 cm and 12.30 cm, respectfully. As suggested by the work of Schonfeld and Beebe, there is a good correlation between stretched penile length and erect length. They suggested that only men with a flaccid length of less than 4 cm or a stretched or erect length of less than 7.5 cm. should be considered candidates for

penile lengthening [2]. The largest study on penile length was published in 2001 by Ponchietti et al., with a sample size of 3000 Italian men. The goal of their study was solely to determine the variability in penile size. Mean flaccid length was 9.0 cm, mean stretched length was 12.5 cm, and mean circumference was 10.0 cm [13]. Schneider et al. looked at the relationship between penile size and problems associated with condom use. Their experimental population consisted of 111 men aged 18–19 years. Measurements were carried out in the flaccid length, and subjects were given calipers to measure penile width, not circumference. The average self-reported flaccid penis measured 8.60 cm, whereas the average erect penis was 14.48 cm [14]. In 2005, Awwad et al. published his series of patients examining penile size in Jordanian men with and without erectile dysfunction. In the 271 "normal" subjects aged 17–83 years, they found that flaccid length was 9.3 cm, stretched length 13.5 cm, and penile circumference 8.9 cm [20]. Dilon et al. [28] summarized the aforementioned data and drew some conclusions regarding penile length and circumference. With respect to penile length, average penile size is 8.91 cm in the flaccid state, whereas the maximally stretched flaccid length is 12.61 cm. Average erect penile length ranges from 14.52 cm, and the average flaccid and erect penile circumference is 9.09 and 12.49, respectively (Table 4.1). Most of the papers had standard deviations of <2 with respect to penile length and standard deviations of <1 when looking at penile circumference. By applying these findings, it is generally accepted that a true micropenis is >2.5 S.D.s below the mean length. This appears to be the patients who have a flaccid penile length of <5 cm, stretched length of <7 cm, or midshaft penile circumference of <8.0. These data are helpful in giving surgeons a starting point as to when penile augmentation might be deemed medically necessary or appropriate. There are several areas where further work is needed. For instance, there is little evidence of racial or ethnic differences. Thus, further investigation will be required. For the issue of age in adult men, while there appeared to be a trend suggesting that men with a greater mean age had smaller penises than those in studies where the mean age was lower, when this question was formally assessed, there were no differences [14].

Indications for Penile Augmentation

Penile shortening is a phenomenon that is associated with certain medical and surgical conditions, including penile cancer, penile trauma, excessive skin loss, prostate cancer treatment modalities, buried penis, Peyronie's disease, and congenital anomalies (epispadias, hypospadias and intesex disorders). There is also some evidence that erectile dysfunction may be an independent risk factor for shortening. The general consensus is that patients suffering from these conditions are candidates for penile lengthening or other reconstructive procedures [29–32]. Specifically, men who undergo radical prostatectomy and possibly radiation therapy and hormonal treatment are susceptible to penile shortening [33–35]. Pelvic surgery, in the form of radical prostatectomy, has also been shown to result in penile shortening. The explanation for this might be a direct consequence of the prostatectomy, but an alternative hypothesis is that, with the onset of erectile dysfunction (ED) caused by the prostatectomy, there is a gradual loss of smooth muscle within the penis, with associated fibrosis and shrinking. This further raises the issue of whether men who have severe ED have smaller penises than age-matched potent men. In 2001, Munding et al. [34] examined penile length in 31 men who underwent RRP by a single surgeon. All men had erections that were sufficient for penetration preoperatively. Penile measurements were recorded in triplicate on all patients in the holding area prior to surgery. These were performed in the stretched flaccid condition only, from the tip of the glans to the pubopenile skin. The same measurements were taken again 3 months postoperatively. No erect measurements were recorded, nor were penile circumferences recorded. They demonstrated penile shortening

in the stretched condition in 71 % of patients; 23 % of patients were found to have <1.0 cm decrease in length, whereas 48 % were seen to have a >1.0 cm decrease in stretched penile length. In 2003 Savoie et al. [35] similarly examined post-RRP flaccid and flaccid stretched penile lengths. Penile lengths and circumference of 63 men undergoing RRP were measured pre- and postoperatively. Measurements were recorded from the pubopenile skin to the meatus, in the flaccid and stretched flaccid conditions. Penile circumference was also measured midshaft. Measurements were taken preoperatively in the holding area and then 3 months postoperatively. About 68 % of patients demonstrated a statistically significant reduction in penile length in both the flaccid and flaccid stretched conditions, but interestingly, an increase in penile circumference was also seen. Etiology of penile shortening is unclear at the present time. Theories include early penile shortening related to urethral shortening due to RRP or secondary corporal fibrosis from chronic hypoxia and fibrosis. There is increasing evidence, however, that penile shortening is not limited to surgical treatments of prostate cancer. Haliloglu et al. [33] looked at penile length in men treated with a combination of androgen suppression and radiation therapy. All subjects received hormone deprivation therapy in the form of a luteinizing hormone releasing hormone (LHRH) agonist, every 3 months for a total of nine injections. Twenty days of bicalutamide (50 mg/day) was given 10 days prior to the LHRH agonist. External beam radiation (70 Gy) was administered in a two-phase four-field approach. Penile measurements were recorded in the stretched flaccid condition from the pubopenile skin to the tip of the glans. They found that there was a statistically significant decrease in penile length in men treated with hormonal suppression plus radiation. More specifically the men who had a pretreatment stretched length of <14 cm had a lower percentage of penile shortening compared to men with pretreatment lengths >14 cm. Although the literature is limited, there is some evidence that external beam radiation can cause penile fibrosis and ultimately penile shortening. The effects of hormone deprivation alone on penile length are not known. Probably the most common etiology of penile shortening is seen in patients with Peyronie's disease. It is important to note that both the natural history of disease and the scarring process after surgical repair with incision/excision of plaque with graft or a penile plication procedure for surgical correction may cause a reduction in penile length [36]. When the disease is circumferential or bilateral, it prevents the tunica albuginea from expanding, thereby causing penile shortening [37]. Surgical procedures for correction can result in fibrosis that can result in further reduction in length when compared to preoperative measurements. Typically, 60–100 % of patients undergoing penile plication procedures will have some degree of penile shortening. In addition, 0–50 % of patients undergoing incision of plaque with graft may have penile shortening [38]. This is likely the result of graft contraction. There is some early data suggesting that a penile extension device may increase length, prevent graft contraction, and minimize postoperative penile shortening [39, 40]. Although penile shortening has been documented in the aforementioned studies, there is no quality-of-life data to support or refute the overall importance of this effect on male sexuality. Along similar lines, patients who have Peyronie's disease are also subject to penile shortening, but much like those treated for prostate cancer, penile shortening is not usually significant enough to warrant penile augmentation surgery. Surgeons who consider performing this type of surgery must be able to justify why augmentation surgery should be performed.

Lastly, congenital micropenis results from a number of biochemical etiologies, and it is lifelong. The biological causes stem largely from defects in the hypothalamus, specifically when an inadequate amount of gonadotropin-releasing hormone is released. This may be a primary hypothalamic or an anterior pituitary problem. The micropenis can result from embryonic testis failure causing insufficient masculinization [39]. Bladder exstrophy and epispadias also can result in penile shortening, thought to be related to a congenitally shortened anterior corporal length [41].

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Psychosocial Perspectives on Penile Size

5

Gahyun Youn

Initial Remarks

Most men of today have at least four concerns on sexual health. First, a number of men worry to ejaculate earlier than they expect while having sex. Thus, they wish to have a longer lasting erection in bed with better control over their ejaculation [1, 2]. Second, penis size is a considerable concern for men of all ages [3]. Many men wish that they had larger size of penises, but the younger generations, especially, place greater concern or importance on penis size than the older generations [4–6]. Third, they wish to have no erectile dysfunction in their lives. In general, the level of depressive symptoms is negatively associated with various sexual functions, especially erectile function [7]. Fourth, they wish they will not lose their sex partners even when they are getting older and older. The older adults feel more anxious when there would have no available sex partner [8]. Among the four concerns, three of them are related to penile erection, while one of them which would be the main topic of this article is the penile size.

Ancient Perspectives

Why do men have concerned or worried about their penis size? The concern or worry might date back over tens of many thousands of years. The ancient people in most cultures, even prehistoric cave dwellers, believed that their leaders and gods had giant penises [6]. According to the belief, larger penis size, particularly in its erect size, had come to symbolize attributes of hegemonic masculinity that would be worth all the patriarchal strength and power. For instance, the larger penis size had been equated with a reproductive power (fertility), a sexual power (virility, sexual conquest), a physical power (stamina, strength), a social power (higher status, economic independence, dominance over men, possession of women), a mental power (ability, certainty, courage, endurance, knowledge, intelligence), and so on [6, 9, 10].

There was a folktale of the greatness of penile size in Korea. The most popular surname in Korea is Kim that might be comprised of over 20 % of the population. Among several family clans of Kim, members of the Gimhae Kim clan trace their ancestry to King Suro (?–199 AD). According to the Korean history, Suro Kim was the legendary founder and king of the Geumgwan Gaya which was one of small countries in southeastern Korea almost 20 centuries ago. It appears from the folktale that King Suro was famous for his giant penis that was used as a bridge. That is to say, the people crossed the bridge on foot instead of crossing a

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small river Sun-Am-Jin in a boat while they did not know what the bridge was made of [11].

Modern Perspectives

How about men of today? They are still sticking to the idea of a so-called phallocentrism that the penis is a symbol of empowerment and to the belief of a so-called phallic identity that the bigger one is better [12].

As for the phallocentrism, a number of men believe that the size of the penis is directly proportional to its sexual power, sexual fitness, and even a man's reproductive capacity [13, 14]. Many men still note that having a large penis is considered by society as a sign of manliness and virility. For instance, men who reported having a large penis has a feeling of greater sexual competence than those reported average- or small-sized penises [5, 6]. Even among men who have sex with men, those who perceived their penises as below average were significantly more likely to identify as bottoms, that is, anal receptors, while those who as above average to identify as tops, that is, anal inserters [10].

As for the phallic identity, penis size is positively related to satisfaction with body image, and thus men who reported having a large penis had more positive genital self-image and body image such as height, body fat level, face, overall physical attractiveness, comfort in a swimsuit, and so on than those reporting average- or small-sized penises [6, 15]. It was found that the symbolism of having a large penis was important across the life span, even though dissatisfaction with penis size only slightly declines as men age [15]. However, the other study reported that the younger men were more likely than the older men to mention penis size as being an important of an ideal physique because their achievements and life experiences would reduce their concerns for masculinity and thus penis size as men age [5].

Cultural Influences

How do men of today perceive their penis size? Some men are worrying that their penis is too small and are insecure about their ability to satisfy their partners sexually because their doubts can have irritating effects on their potency [14]. That is, penis size affects sexual behaviors, and thus men with smaller penises were less likely to undress in front of their partner and more likely to try to hide their penis during sex [15]. The insecurity and doubts on their sexual appeals would be almost the same to those of women who have reluctance to show their bodies to sexual partners if they consider their breasts to be small [14, 16]. Men who perceive their penis size as small feel embarrassment and fear of being mocked and thus are socially withdrawn and isolated [17].

As aforementioned, penis size is very much related to body image. Researchers have also found that those who are dissatisfied with their bodies have fewer sexual experiences, engage in fewer types of sexual activities, feel less sexually desirable, and experience more sexual problems than those who are satisfied with their bodies. During sexual situations, those with poor body image also experience lower sexual self-esteem and assertiveness and greater sexual avoidance and anxiety [18, 19]. According to the survey of several thousands of Finnish men who aged 19–49 years, higher levels of genital satisfaction correlated with better sexual functioning and higher frequencies of sexual behavior. Men who were satisfied with their genitals reported significantly higher frequencies of kissing, petting, oral sex, and vaginal intercourse. Men who were dissatisfied with their penis size experienced premature ejaculation more frequently and decreased erectile function [20].

Fear and anxiety about penile size might also arise after the breakdown of a relationship with a partner or after derogatory or malicious remarks made by the partner during sexual activities. For instance, the receptive partner might report that she or he cannot feel the man inside during sexual intercourse. This might lead to poor sexual self-confidence, with a tendency to feel inadequate in vulnerable public situations, and this in turn might prevent the man from establishing further (or any) intimate relationships [6]. Men's concerns about penis size are fueled by cultural messages that a large penis is relate to manhood, masculinity, and virility. Popular media, such as TV and men's magazines, frequently emphasize

the connection between penis size and masculinity. Especially, pornographic movies and Web sites featuring men with very large penises reinforce the cultural message associating large penis size and masculinity. Female actress exaggerated sexual responses to overly endowed male actors in these pornographic images may also convince men that women have strong preferences for large penises. Most men are aware that the penises in these pornographic images are atypically large, but persistent exposure to these images may cause men to overestimate the average penis size and underestimate the size of their own penises. Men's worry about their personal inadequacies has created a large market for penis enlargement products and procedures [5, 15, 17, 21].

Social Comparison

Many men tend to perceive their penis to be smaller than an average penis [22]. They also tend to underestimate their own penis size [17]. Thus, they are often troubled by concerns that their penis may not be large enough to satisfy their partners or themselves. They are ashamed to have others view their penises, particularly in the locker room. They do not accept their penis size which is objectively normal, especially in the flaccid state. They compare their penis with that of the other men of their age and believe that their penises would be smaller. The connection between their concern and penis size has been examined through the lens of social comparison theory [17, 23, 24].

Social comparison theory fits well with sociocultural theory and is commonly used when addressing body image and sexuality. The theory suggests that individuals compare themselves to others in order to form self-assessments. These points of comparison tend to be of traits or characteristics that the individual believes to be of importance. If these comparisons are done with others who are more gifted with regard to that particular attribute, it is termed "upward comparison." These types of comparisons typically result in negative affect. However, if the comparisons are done with others who are less gifted with regard to the particular attribute, then it is termed "downward comparison," which often brings about an increase in one's self-esteem. That means some men can have a feeling of superiority over guys with scaled-down penis, while the other men can have a feeling of inferiority over guys with scaled-up penis [17, 25, 26].

Interestingly, there are more men who resort to upward comparison for their penis size than downward comparison. Most men who request surgical penile enhancement have a normal-sized and fully functional penis but perceive their penis as smaller than those of the other men or real size and are mainly concerned about their flaccid penile size, the so-called locker room syndrome [27, 28]. Such concerns might be unfounded in reality and might be a presentation of social anxiety or some other clinical problem, such as erectile dysfunction. Concern over the size of the penis, when such concern becomes excessive, might present as the "small penis syndrome," an obsessive rumination with compulsive checking rituals, body dysmorphic disorder (BDD),[1] or as part of a psychosis [6]. Individuals with BDD are preoccupied with one or more perceived defects or flaws in their physical appearance, which they believe look ugly, unattractive, abnormal, or deformed. Preoccupations can focus on many body areas including genital parts. Excessive repetitive behaviors and mental act (e.g., comparing) are performed in the response to the preoccupation. The preoccupation causes clinically significantly distress or impairment in social, occupational, or other important areas of functioning [29]. Men with BDD related to the size and appearance of their genitals frequently develop major depressive episodes and are at risk for suicide [6].

Perceived Penis Size

According to a large Internet-based survey of 25,594 heterosexual men, about two-thirds of them (66 %) rated their penis as average, 12 % as small, and 22 % as large [15]. But almost 45 % of

[1] BDD is one of obsessive-compulsive disorders and also known as dysmorphophobia in the past.

men were unhappy with the size of their penis and desired a larger penis [6, 15]. A fair number of men who rated their penis size as average felt discontented with their own size. Those men who perceive their penis size as small tend to report or rate their penis size as average because they feel discontented when they report or rate the size as small. It means they wish they had a larger penis than a real one [26]. As for men who have sex with men, 56.0 % of them perceived their penis as average, while 36.9 % as above average, and 7.1 % as below average [10].

In general, measured penis size made by sex researchers tends to be significantly smaller than self-reports by male respondents. However, the crucial point may not be actual size but rather a man's perception of the size of his penis relative to other men's [15]. Many men who perceived their penis size as small tend to compare only to other men who have larger penis. They do not understand exactly what the objective methods of penile size evaluation or the normal range of average size would be. So, some men are unnecessarily worrying about their penis size and wanting penile augmentation surgery [6, 21, 30].

Then, how do women rate men's penis size? According to a large Internet-based survey on 26,437 women, 84 % of women were not dissatisfied with the size of their partner's penis size at all. Most women rated their partner's penis as average or large, and almost of them reported they were satisfied with his penis size. However, some women judged their partner's penis as small, and the majority of them reported they were not satisfied [15]. Another study also reported that about 85 % of women were not dissatisfied with their partners' penile size [6].

The other researcher asked the Croatian women ($n=566$) who aged 19–49 years old how important the penis size would be in their sexual pleasure. Penile girth was found to be more important than penile length. A fifth of respondents (21.8 %) reported that they found both girth and length unimportant, while 12.8 % judged both qualities very important. The more sexually experienced women (i.e., having larger number of lifetime sexual partners), the more important they judged penis size as well as penis girth. In addition, as for the question of how important the overall esthetic quality (appearance) of their partner's penis would be for their satisfaction, 26.9 % of the respondents judged it to be very important, 44.9 % somewhat important, and 28.2 % unimportant [31].

Girth Versus Length

When people speak of penis size, they typically refer to length. Thus, a man with a short but wide penis would probably think of himself as having a small penis and would be so thought of by others, too. However, width is part of size, although usually not acknowledged. Thus, the female students who aged from 18 to 25 years old, in person or via telephone, were asked "In having sex, which feels better, length of penis or width of penis?" [32]. In a half the cases, the word "width" was used before the word "length," but there were no order effects. There were also no effects for telephone versus personal interview. Of the 50 females surveyed, 45 reported that width felt better, with only 5 reporting length felt better. No females reported that they could not tell any difference. Also, about 20 % of the women found the length of the penis important and 1 % very important; 55 and 22 % of the women found the length of the penis unimportant and totally unimportant, respectively. Opinions about the girth of the penis followed the same trend. After all, length was less important than girth [13, 32].

In general, discontent over penis size would be greater in men than women. That is, women's discontent over their partner's penis size was not serious when comparing with men's discontent over their own penis size. However, the certain thing would be that some women obviously complain of the male partner's penis size, and then he might consider the penile augmentation surgery in order not to lose self-confidence. Of course, penis width needs to be given more consideration and taken into account when one discusses penis size or considers the surgery [32].

Medical Necessity

If most women are not dissatisfied with their partner's penis size, then most men's concern on the size of their penis might be unnecessary [15]. However, some women are dissatisfied with and even accuse their partners of having modest-sized genitals. It is the same maliciousness that drives some men to mock their partners' small breasts [14]. Thus, many men feel a need to enlarge their penis in order to improve their self-esteem or to satisfy and impress their partners. After all, some of them take account of surgical lengthening or thickening procedures earnestly [13]. As a matter of fact, penis size, either flaccid or erected, was not mentioned, discussed, or defined even in serious books of human anatomy until the mid-1980s [14]. A number of plastic and urologic surgeons have attempted to enhance the penile length and girth of healthy men for purely cosmetic reasons since the 1990s [24].

Here, the surgeons should take account of the following several things before operating the surgical procedures. For instance, they should know the following: "Why are the men paying heavy money for extra size on a flaccid penis?" "Are surgery able to reduce anxiety or depression levels for the men?" "Does surgery affect their sexuality such as increasing their sexual power?" But a study showed that on average, these procedures elongate the external part of the penile shaft by only 1.3 cm, and thus the overall patient satisfaction rate was only 35 % and much lower in the group with the penile dimorphic disorder because they had unrealistic expectations regarding the outcome of surgical intervention. In general, penile enhancement surgery can cause a 1–2 cm increase in penile length and a 2.5-cm augmentation of penile girth but usually not to a degree that satisfies the patient [33]. By nature, some patients would never be satisfied no matter how perfect the operation. To make matters worse, unwanted outcomes and complications such as penile deformity, paradoxical penile shortening, and sexual dysfunction were reported frequently in many studies [28].

Final Remarks

The surgeons should be very cautious about executing surgical treatments because those who are not satisfied with the outcomes of the treatments can be vociferous and/or sometimes turned violent. Then, why are they dissatisfied with the results? Would the reason of their dissatisfaction be that the size was not large enough than they expected? As mentioned earlier, most women who reported their partners' penis as small were not satisfied [6]; some men report that their partners have left them because of small penis size [31]. However, there is a report that some men manage a reasonable sex life with a micropenis [34].

What do the contradictory statements mean? The main reason why woman would be dissatisfied with her partner's penile size might not be the size itself but the man himself. To men's great regret, they don't know the women's perspectives well. Many men believe that women may have complaints of smaller size and thus prefer to larger one. Therefore, even some men in stable relationship with their partners with a normal penis choose to undergo penile lengthening owing to the belief that the bigger the better to make women satisfied. Judging from my consulting experience, most men do not consult their female partners about their opinion concerning their penile size. Accordingly, it is highly desirable for the surgeons to ask the man if his partner would know of and/or agree to the penile augmentation treatments.

With this question, the surgeons should deliver him the typical outcomes of the treatments. Urologists and psychotherapists often encounter patients who complain about the length of their penis, but these patients are usually well within the typical range for penis size [15]. Thus, the surgeons should advise the man, who is dissatisfied with the appearance of his penis, to think very carefully before requesting the treatments that are experimental and high risk, especially in cases where the penis is normal. As a better option, he should be guided to seek the counsel of psychologists because he simply needs to be

reassured that his penis is "normal" or needs advice on how to better satisfy his partner without resorting to the treatments. Unfortunately, however, there will always be men willing to undergo penile enlargement or "beautifying" surgical procedures in an attempt to feel better. Thus, it is the responsibility of every professional involved in sexual medicine to provide balanced and well-supported advice on these issues. Self-confidence and beauty come from the inside, and no surgery is deep enough to change that [24, 27].

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6 Preoperative Preparation, Postoperative Care, and Complication Management

Jun Hyuk Hong

Introduction

The need to perform surgery to enlarge the penile girth remains under controversy because of patient's satisfactoriness as to the surgical outcomes and complication rates. But the demand for this type of treatment is growing; therefore, we should approach this operation step-by-step.

Preoperative Preparation

Before the operation, prudent patient selection and in-depth counseling including psychological perspective (see Chaps. 4 and 5) should be done, and informed consent with the detailed explanation of probable complications should be received from the patient. Patients should be informed of the many complications that can result from procedures, even leading to shortening of penile length and sexual dysfunction [1]. Surgeons who consider performing this type of surgery must be able to justify why enlargement surgery should be performed.

For the dermal fat graft, patient should have low-fat diet for 2–3 weeks before surgery so that adipocyte contains lesser amount of fat. The less fat the adipocytes have, the higher success rate of graft survival can we expect owing to the less production of fat from destroyed cells.

Preoperative preparations were described in detail by Panfilov [2]. Before surgery (prior to arrival at the clinic), the patient must shower his body with a mixture of betadine solution and body shampoo. Patients also must have their pubic hair shaved. In the operating room, the patient receives a second washing with concentrated betadine solution. Penile augmentation with or without elongation is much comfortably conducted under general anesthesia. Penis augmentation using subcutaneous injection or autologous fat transfer may be conducted using intravenous sedation combined with a penile root block.

In case of allografts, graft materials fashioned to wrap around the penile shaft are used. They are prepared from cadaver and are chemically treated (AlloDerm, LifeCell Corp., Branchburg, NJ) or sterilized using radiation (Repriza, Promethean Science, Pittsburgh, PA). Other kinds are derived from living donor (Belladerm, MTF, Edison, NJ).

Postoperative Care

Penile augmentation surgery is prone to infection because the skin of the penis is thin and has considerable swelling after surgery. If we cannot control edema in penis, it could lead to wound dehiscence and graft exposure. In case of dermal fat graft, only

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after the graft has sufficient blood supply, it can resist infection. Using compressive dressing materials, wound dressing should be done not too tightly. To prevent infection, broad-spectrum antibiotics were administered for 3–5 days.

After surgery, ibuprofen has so far offered the best results in terms of stomach friendliness while keeping effectiveness high. Most patients leave the clinic on the day of surgery or the next day.

Complication and Its Management

Acellular dermal matrix materials have been used in penile augmentation increasingly. There are lots of manufacturers of these products as described above, and we have few reports comparing one product from another in its efficacy or complications. A large series with breast reconstruction using acellular dermal matrix reported no difference among various types of materials in complications [3].

The most worrisome complication is infection. Solomon et al. reported 42 % of infectious complications in 47 patients with allografts during median follow-up period of 11.3 months [4]. They defined infectious complication as graft exposure requiring antibiotics with or without surgical revision or graft removal. In 3 patients (6.4 %), infection was not controlled and grafts were removed. Culture results revealed various causative agents such as *Enterococcus, Streptococcus, Klebsiella pneumonia, Escherichia coli, and Staphylococcus aureus*.

Dermal fat grafts were reported to have initial short-term satisfactory results, but at 8 weeks, most of the fat is replaced by fibrotic tissue. This technique has significant disadvantages such as prolonged operative time up to 7 h and a high incidence of postoperative complications including postoperative penile edema and induration, venous congestion, and skin injury [5]. Donor site scarring or deformity, and curvature, asymmetry, and penile shortening may occur. Even with the significant risk of fibrosis, girth enhancement is achieved at higher rates when compared to fat injections [6]. Chronic complications of dermal fat graft include epidermoid cyst and seroma. Epidermoid cysts usually present within 2 weeks arising from sebaceous gland or hair follicle of dermis. Seroma develops from fat derived from destroyed adipocytes. When their amount is small, they will absorb spontaneously. If there is large amount, it can be relieved by careful aspiration using 18-gauge needle.

Hyaluronic acid gel injection was mainly used as "tissue filler" for glans penis augmentation, and it also is used for penile girth enlargement. Kwak et al. reported results with injectable hyaluronic acid gel [7]. They injected 18–22 ml, and penile girth was changed from 7.48 ± 0.35 cm to 11.41 ± 0.34 cm at 1 month ($P < 0.0001$) and maintained as 11.26 ± 0.33 cm until 18 months. There were no inflammatory signs.

Panfilov [2] reported that the injection of 40–68 ml of autologous fat resulted in 2.6 cm increase in penile girth. Large amounts injected at multiple sites leave only 10 % of the fat cells intact [8]. Complications include nodular formation, calcified fat, penile deformities, and, in extreme cases, sclerosing lipogranuloma [5].

Sometimes foreign body materials were injected subcutaneously by nonmedical practitioners under non-aseptic condition. There were many case reports with complications from such materials as paraffin [9], Vaseline [10], or even metallic mercury [11].

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Part II

Penile Girth Enhancement

General Conception of Penile Girth Enhancement

7

Sae Woong Kim and Mariano Rosselló Gayá

Introduction

Penile girth enhancement, widening, and broadening are different terms to describe procedures that increase the diameter of the penis [1]. The injection of exogenous materials into the penis or stretching with external weight has been popular in different cultures with the focus on "bigger is better" [2]. Man's eternal desire for a bigger penis has resulted in many penile lengthening and girth enhancement techniques being described. Men need to enlarge their penises in order either to improve their self-esteem, to enhance cosmetic appearance, or to satisfy their sexual partner If penile prosthesis is implanted erection must be present [3].

Micropenis, normally formed but is small in size with a length of 2.5 standard deviation below the normal median, is generally regarded as the indication of surgical correction. However, almost all men who want penile enhancement procedure usually have a normally sized and normally functioning penis [4]. Penile girth enhancement is more controversial than penile lengthening. The causes of controversy are no recommended indication for this procedure in the medical literature and no guidelines for penile girth enhancement due to lack of any esthetic or other indication for this technique [5]. Although there is lack of sufficient data associated with penile girth enhancement, various materials have been tried by medical or nonmedical personnel to be injected in the subcutaneous layer of the penis to gain penile enlargement and augmentation. Injectable materials used for penile enhancement such as paraffin, mineral oil, metallic mercury, and petroleum jelly (Vaseline) can cause severe complications such as Fournier gangrene, erectile dysfunction, and abscess formation [6–9]. Autologous fat and liquid silicone are widely used as safe for penile girth enhancement. The advantage of autologous fat and liquid silicone is convenience of injection to the penis. However, the disadvantages include nodular formation, fat necrosis, reabsorption, penile distortion, and late granulomatous reaction [10–12]. Current available girth enhancement techniques except for injection include autologous graft using dermal fat or vessel, allograft using synthetic filler, and flap augmentation. Graft procedure showed prominent enlargement of the penis compared to injection technique. However, the complications such as persistent postoperative penile edema, induration, venous congestion, erosion, fibrosis, infection, resorption, and skin loss might happen, if not performed following protocols and by experienced surgeons.

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Materials of Penile Girth Enhancement

A dermal fat graft is a dermis-free graft that comprises all layers of the skin and the underlying subcutaneous tissue after removal of the epidermis [13]. Autologous dermal graft or dermo-fat graft around the corpus cavernosum may provide outstanding results in penile girth enhancement with a low complication [10, 14]. The acceptance of and survival of the grafted fat tissues depend on a quick, atraumatic, sterile transfer of the graft and its early revascularization. Final outcomes depend mainly on the amount of fat which is reabsorbed and replaced by fibrous tissue and on the remaining thickness of dermal tissue. Although the risk of partial graft reduction or fibrosis is significant, girth enhancement by dermal graft is accomplished at higher rates when compared with fat injection technique [15].

Autologous fat injection into the penis is the mainstay of girth enhancement procedures. The purpose of fat injection inbetween tunica albuginea and bucks fascia is uniform enhancement of penile diameter. Results for autologous fat injection are regarded as unpredictable due to the lack of an adequate blood supply to the injected fat tissue, and no plane into which the adipocytes are injected has been determined [16]. Panfilov [11] reported his procedure of injecting autologous fat into penile shaft. Instilled into the upper inner thigh was 200–250 cm^3 of physiologic solution containing adrenalin and Xylocaine. Harvested body fat was injected between the fascia penis superficial and the profunda through four 1 mm incision of inner prepuce. When the 40–68 ml of autologous fat injections was finished, the penile shaft needs to be kneaded to even out the injections. Seventy seven patients were highly satisfied, eight patients were fairly satisfied, and three patients were not satisfied at 1 year follow-up.

Penile augmentation with allograft placement is not a common procedure [16]. However, this procedure has been executed for many years, and many kinds of allograft materials have been used. Soft tissue fillers include both bovine and human collagens, the hyaluronans, calcium hydroxyapatite, poly-L-lactic acid, and synthetic polymers [17]. AlloDerm (LifeCell Corporation, Branchburg, NJ, USA) is an acellular dermal matrix derived from donated human skin. Although most of the recently reported data about AlloDerm are anecdotal, they have been widely used for penile girth enhancement. The advantages of this material are good graft survival, no donor-site scarring, and low complication rate. Outcomes of InteXen (American Medical Systems, Minnetonka, MN, USA) that are made by an acellular dermal matrix porcine graft were reported recently [18]. They concluded that the advantages of this graft are the lack of donor-site morbidity and a significant decreasing operation time. However, disadvantages included fragility, making it necessary to put more sutures to fix the graft, and detachment during the procedure. Girth enhancement using injection of hyaluronic acid gel into the fascial layer of penile shaft was reported [19]. Maximal circumference of penile shaft increased from 7.48 ± 0.35 cm to 11.41 ± 0.34 cm and maintained as 11.26 ± 0.33 until 18 months. No complications were reported at follow-up period.

Liquid silicone has been used for soft tissue augmentation. However, the injection of liquid silicone into the penis shaft is highly controversial. Although liquid silicone injection of the penis was reported first in 1973 by Arthaud [20] and the use of liquid silicone for penile girth enhancement has been described, it has not been recommended, owing to the development of many complications including pain, ecchymosis, pigment change, or, most catastrophic, pneumonitis or embolism if the silicone is injected directly into the vascular system [21, 22]. Furthermore, injection of liquid silicone into the penis increases the possibility of damaging blood vessels and nerves, thereby causing loss of sensation and erectile dysfunction [23]. However, large number (327 men) series of experience with penile girth enhancement using liquid silicone was reported [24]. Authors conducted material injections between the penile skin and the corpus cavernosum on the dorsal and lateral side of the penile shaft. Mean diameter of penile circumference was changed from 9.5 cm preoperation into 12.1 cm postoperation during 20 months follow-up. They commented that penile girth augmentation using liquid

silicone attains very satisfactory outcomes in the early postoperative phase.

Various artificial oils such as paraffin, mineral oil, and petroleum jelly for penile enlargement have been tried [6, 8, 9, 25]. Since injection of not-approved materials is performed by most nonmedical persons, complications occurred frequently. Paraffinomas result from a foreign substance containing straight-chain saturated hydrocarbons, such as paraffin of mineral oil. The lack of the enzymes to metabolize interstitial exogenous materials provokes consequently a foreign body reaction [26]. The complications emerge several months to years after injection. The skin initially becomes sensitive at the part of injection, with visible depigmentation or a dark, yellowish discoloration. Reactive fibrosis in the adjacent tissue leads to erectile dysfunction, phimosis, or priapism. As the paraffinoma progresses, there may be development of fistula or multiple, painful deep ulcers and areas of necrosis into which the paraffin can be drained [6, 27].

Other types of girth enhancement of the penis were reported. Austoni et al. [28] described corpora cavernosa enlargement augmentation using bilateral saphenous vein. The increased volume of corpus cavernosum was accomplished by placing segments of saphenous vein into the tunica albuginea along the lateral aspect of each corpus cavernosum. At the 9 month follow-up, the increase in the diameter of the penis during erection is between 1.1 and 2.1 cm as compared with the preoperative measurement. The advantages of autologous saphenous vein graft are the lower incidence of postoperative fibrosis and occlusive vein pathology because the endothelial linings are compatible. Shaeer et al. [29] reported the first application of a flap augmentation using superficial circumflex iliac artery island flap. At 6 months follow-up the gain of erect and flaccid girth was 8.5 and 9.5 cm.

Different authors have commented about the benefits of enriching the fat grafts with stem cells which are obtained from the same adipose tissue. Little proof of this has been published in regard to penile augmentation in comparison with the publications regarding this therapy in breast surgery. It is believed that cells from the stromal vascular fraction will aid the adipose tissue to nest in its new location; this has been proved "in vitro" [30, 31].

Conclusions

Penile size is regarded as important for sexual interaction between men and women. Penile enhancement can be acceptable when procedure results in successful data with minimal complications. Although the use of varying materials and tissues for penile girth enhancement has been reported, results of penile augmentation are still controversial, and there is little medical literature documenting safe and efficacious materials. Therefore, there is a need to execute prospective randomized clinical trials on large scales and to develop validated methods for evaluating subjective and objective perception of penile girth diameter, together with procedure protocols.

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Penile Girth Enhancement with Dermofat Graft

8

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Introduction

Autologous dermofat graft is the commonly operated procedure for its advantages with not only the rich volumes of dermis and fat to collect in human body with easy tissue harvest character but also relatively high graft success rate of tissue and low fat absorption for the penile augmentation. And the survival mechanism of dermofat graft, preoperative preparation, and the surgical procedure are as follows [1].

Survival Mechanism of Dermofat Graft

Dermofat graft is a procedure to transplant the fat to subdermal recipient site, but in terms of tissue structure, it is a complex graft [2]. The posttransplant engraftment mechanism of adipose cells is still not known completely, but there are some theories about the mechanism available such as the host cell replacement theory and the cell survival theory [2–4].

1. Host cell replacement theory: This theory addresses that the grafted adipose cells are degenerated and the fat released from the cell is absorbed and gradually eliminated by histiocyte of the host, and then new cell is formed.
2. Cell survival theory: This theory addresses that a large quantity of grafted adipose cells survives owing to abundant blood circulation through subdermal vascular network of graft site and intradermal vascular network of grafted dermis. This mechanism of cell survival is known to be based on early establishment of circulation through the host-graft vascular anastomosis in dermal side. In particular, the abundant blood flow of penile dartos fascia provides an appropriate bed where the fat graft can be well taken. The fat grafts survive by body fluid absorption so-called plasmatic imbibition during the first 24–48 h after transplant. The blood vessel growth incurs between 48 and 72 h after transplant, and the first microvascular circulation is to be observed on 4th day of grafting and it will increase until 6th day. During this time, many numbers of histiocyte, polynuclear cell, eosinophil, plasma cell and lymphocyte appear and histiocyte as well as polynuclear cell serve to engulf the leaked fat. Around 10th day, postoperative neovascularization of microvessel and increase of fiberblast are observed from the recipient site. The notable congestion disappears on 6–8 months after the surgery presenting the normal fat tissue, but the fibrous tissue around the grafted dermofat that contains fibroblast is not completely resolved showing the pattern of the encapsulated

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lipoma. If the graft fails to survive, the tissue fluid is observed for more than a month after the surgery, and they are phagocytized with adipose cells by increased histiocytes and giant cells. One month after surgery, the adipose cells have been absorbed mostly and only scar tissues were left at around postoperative 1 year.

Preoperative Preparation

Start a low-fat diet from 2 to 3 weeks before surgery so as the adipose cells contain a small amount of fat. When the smaller the fat content is, the more release from degenerated adipose cells is reduced so that the surgical operation becomes easier and the take rate of adipose cells can be improved. Thereby, the graft success rate of tissue harvested from thin host body is higher than those harvested from obese host. Thoroughly disinfect the recipient site as well as the donor site and administer antibiotics prior to operation.

Surgical Procedures

The surgical procedures can be performed with no problem if being well equipped with the concept of skin graft and basic surgical techniques (Fig. 8.1).

1. Harvest of graft: When the donor site of dermofat is determined (Fig. 8.2a), position the patient to a posture appropriate for harvest under anesthesia. Graft harvesting sites to be selected are the upper and lower wrinkle area of the buttocks, lower abdomen, lateral abdomen, inner thigh, or medial upper arm. The buttocks have large volume of tissue and the postoperative excision site is not visible as advantages, but it has a disadvantage that the posture needs to be changed during the surgery. The donor site of the graft will be marked in accordance with the length and girth of the penis using a surgical pen prior to incision. For the adequate size of graft, it is appropriate to harvest the volume of 20–30 % more based on the size of recipient site, considering the fat absorption rate. And it is better to harvest the graft as a large lump rate than several small pieces because it can decrease the fat absorption [5].

   In the surgical procedure, at first excise the epidermis by a thin split thickness method from the donor site to be marked in appropriate oval shape with surgical pen corresponding to the size of recipient site, using for Reese Dermatome set (14/1000th inch), Bard-Parker size No. 5, or a shaving razor. At this time, with the epidermis, superficial dermis can be excised also in part (Fig. 8.2b, c). Damage to adipocytes should be minimized by avoiding unnecessary manipulation to the harvested fat, as the absorption rate of grafted fat is proportional to the trauma on the surgical procedure. After harvesting the dermofat tissue, the donor site is covered with gauze sufficiently soaked with the antibiotic-containing saline solution with meticulous hemostasis.

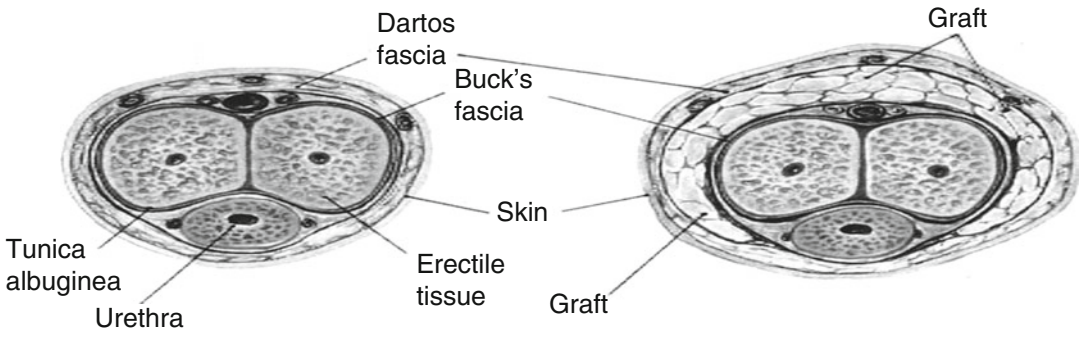

Fig. 8.1 Schematic diagram of dermofat graft for penile augmentation

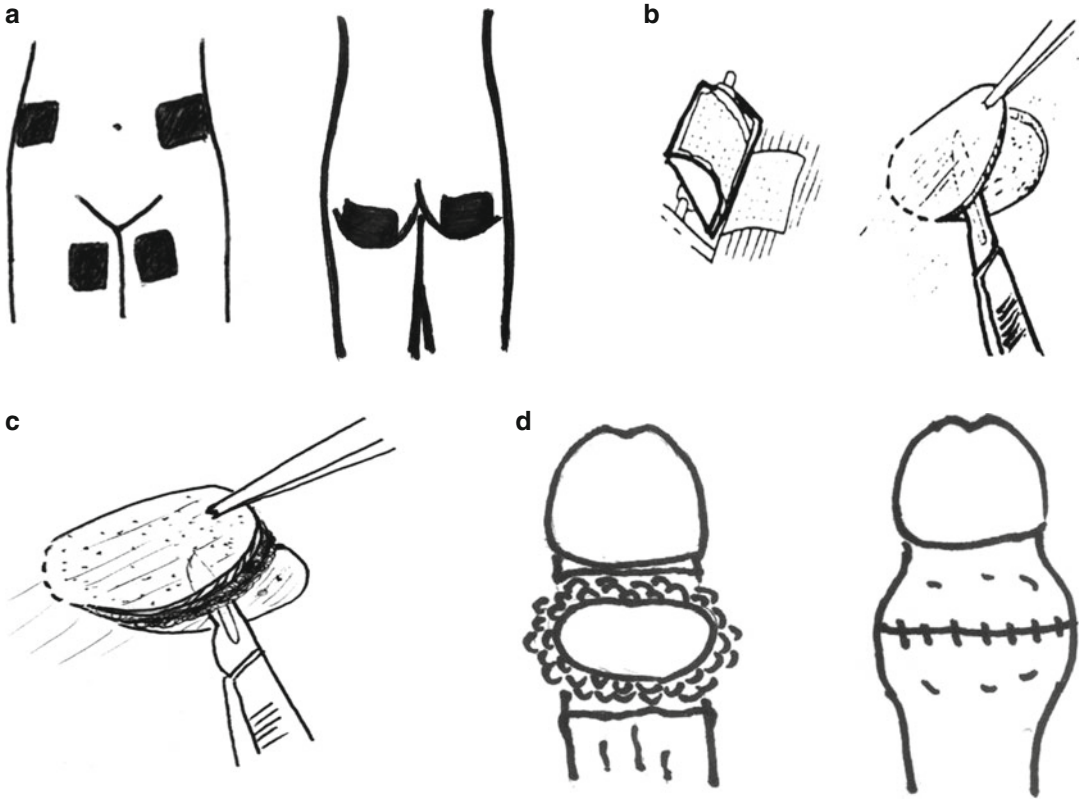

Fig. 8.2 Autologous dermofat graft. (**a**) Selection of donor site. (**b**) Dissection of epidermis. (**c**) Splitting dermofat graft from donor site. (**d**) Fixation of dermal fat graft and wound repair

Harvesting the fascia together with the dermofat has the advantage that the blood circulation is well preserved, and it facilitates the absorption of the exudate [6]. In addition, the pedicle graft incorporating the technique of the microvascular surgery to compensate the disadvantage of free graft may be considered [7]. For the penile augmentation, the dermofat with paramedian flap is being used with relative easiness, which is fed by suprapubic branch of superficial external pudendal artery in terms of distance from the penis. The pedicled dermal fat grafting has technical difficulties, but it also has advantages of less fat absorption from the sufficient blood supply to the graft and being able to transplant a large amount of fat.

2. Incision of the recipient site: The skin below coronary groove of penis should be incised by circular or longitudinal mode, and then sufficient pocket should be secured in the time as fast as possible where the harvested dermofat is placed by dissecting up to the Buck's fascia. And ensure to make the sufficient blood supply to the grafted tissue by resecting enough scar tissues and by completely removing the bleeding or blood clots.

   By widening the space where the graft is to be placed using a penile stretcher or an external cutaneous expander as preoperative adjuvant methods to maximize the surgical outcome, it is possible to prevent any postoperative graft necrosis or to increase the graft success rate.

3. Fixing of the graft and wound closure (Fig. 8.2d): The harvested tissues should be engrafted as soon as possible to prevent drying of the tissue thereby reducing the opportunity for infection. For the graft, usually the juxtaposition method to place the fat side of grafted tissue as parallel to the base of the

recipient site is commonly used, but sometimes a reversed position is also available. The reversed position is advantageous as it can reduce the size of fat tissue when the fat layer of the graft is excessive. After placing dermofat graft in the pocket with fixed suturing with 4-0 Vicryl at 6 o'clock, suture densely in the order of subcutaneous tissue and skin in order by 4-0 Vicryl, respectively, ensuring the fat is not protruded. Here at, the thicker sutured layer of penile subcutaneous tissue, the smaller the skin tension is better.

4. Closure of the donor site: The deep fat layer of the donor site and the subcutaneous tissue are closed with 4–0 Vicryl by interrupted layer-by-layer suture and followed by the skin closure using 5-0 Nylon vertical mattress or American suture.
5. Postoperative management: A urinary catheter is removed on postoperative 1st day, and administer oral antibiotics for 5–7 days to prevent infection.
6. Postoperative results: The changes of penile girth and length by autologous dermofat graft may vary depending on the surgeon's skill, surgical procedures, and follow-up period. In Korean literatures, the reported increase in the penile girth was 65.7–80.0 %, and in penile length, it was from 14.3 to 70.1 % (Fig. 8.3 and Table 8.1) [8–10].

Complications

1. Edema and redness: At the postoperative early stage, either a dark red or dark brown edema, ecchymosis with or without polished look of penile skin, are to be observed. Most of them can be spontaneously resolved by light compressive dressings. When the effusion is retained continuously, it requires aspiration removal. In severe cases, edema or redness lasts for about 6 weeks after surgery, and mostly they are spontaneously healed.
2. Infection: It is important to disinfect the skin of donor and recipient sites thoroughly and to administer antibiotics preoperatively in order to prevent infection. During operative procedure, the harvested dermofat is mandatory to be grafted as soon as possible to prevent the drying of the tissue and to reduce the chance of infection. If an infection is accompanied to the recipient site, the dermofat can be dissolved and dermal necrosis is so far as to incur. If it is determined as a wide-range infection, the graft can be removed as early as possible and revision surgery should be planned at a minimum of 3 months after. If the thickness of dermofat graft is more than 1 cm, the dartos fascia and the skin at the upper site are compressed and such compression-induced venous blood congestion may cause complications such as infection and skin necrosis.
3. Skin necrosis, wound rupture, fat protrusion: The edge of the sutured wound can show skin necrosis due to a blood flow disturbance caused by high tension from excessive skin graft placement. If clinically indicated, re-suturing after partial resection and debridement of the graft is necessary.
4. Penile curvature: The penile curvature can be accompanied due to the penile asymmetry due to a partial necrosis of the graft or failure of symmetric placement [3, 5]. The failure in symmetric placement of the graft can be frequently accompanied due to longitudinal incision or semicircular incision of the penile recipient site. If patient has a severe penile curvature, graft reforming or second graft should be considered carefully. If there is severe penile curvature, a dermatological plastic surgery or reimplantation should be carefully considered.
5. Epidermal cyst: Harvested dermofat is to be removed only in the epidermis that has no nerves or blood vessels, so the subcutaneous glands such as pilomotor muscle, hair follicles, and sebaceous glands in the dermis will remain permanently. However, it has been known that sebaceous glands and hair follicles disappear by degenerative changes within postoperative 2 weeks and within 2 months, respectively, and the sweat glands remain and function for more than a year [1]. Therefore, the epidermal cyst usually occurs from seba-

Fig. 8.3 Preoperative and postoperative findings of dermofat graft for penile augmentation. (**a**) Case I (preoperative). (**a**) Case I (postoperative 1 week). (**b**) Case II (preoperative). (**b**) Case II (postoperative 1 month)

ceous glands or the hair follicles in around 2 weeks after the surgery, but eventually most of them turn into fibrosis or disappear through the course of rupture and engulfment. In severe cases, most of them spontaneously disappear by one or two times of 18 G syringe aspirations.

6. Seroma: This occurs by retention of leaked fat fluid and exudate from destroyed adipose cells, and if it is small amount, mostly it is spontaneously absorbed and yet it may be helpful to puncture with a syringe.
7. Absorption of graft: The operative manipulation may become easier or the uptake rate of grafted fat cells may increase by having preoperative low-fat diet from 2 to 3 weeks before surgery which would be resulted in reduction of the fat fluid leaking from destroyed cells as

Table 8.1 Comparison of results of autogenous dermal fat graft in Korean literature

	No. cases	Preoperative stature mean ± SD, (cm)		Postoperative stature mean ± SD, (cm)		Follow-up period (mon.)
		Girth	Length	Girth *(%[a])*	Length *(%[a])*	
Woo et al. (1996)[b] [15]	24	–	6.0	- *(–)*	8.5 *(41.7)*	1–12
		(6.0–8.0)	(3.0–8.0)	(11.0–13.0)	(5.5–12.0)	
Lee (1997) [16]	1021	6.8	4.8	11.5 *(69.1)*	8.2 *(70.1)*	3–36
		(5.5–8.5)	(2.5–7.5)	(10.0–15.0)	(5.0–11.5)	(16.2)
Lee (1997)[b] [17]	10	6.5 ± 1.2	4.5 ± 1.1	11.7 *(80.0)*	6.9 *(53.3)*	–
Park (1998) [9]	13	7.0 ± 1.0	5.6 ± 0.5	11.6 ± 1.5 *(65.7)*	6.3 ± 1.2 *(14.3)*	3–20
		(6.0–8.0)	(5.0–6.5)	(10.5–13.5)	(6.0–7.5)	(12.6)
Cho (1998) [10]	617	–	–	4.9 ± 0.86[c] *(–)*	3.6 ± 0.73[c] *(–)*	3

[a]Percentile changes from preoperative stature
[b]Performed simultaneoulsy with V-Y plastu or suprapubic lipectomy
[c]Difference between pre. and post op. size was described only

allowing adipose cells to contain small amount of fat. Post-graft tissue absorption rate varies according to the tissues. It has been known that the absorption rates of fat, dermofat, and dermal tissues after graft were approximately 50 %, 20–30 %, and 15–20 %, respectively [1, 3]. Therefore, in consideration of the fat absorption rate, it is appropriate to harvest the corresponding amount. In addition, a large chunk of harvested graft can reduce the fat absorption rate compared to a number of small pieces [2].

8. Calcification of the graft: It is a very rare complication of the procedures, which develops from mixture of hydrolyzed fatty acids, insoluble calcium, and calcium salts a few years after graft. There are no subjective symptoms, and many cases are being found incidentally by chance from the radiography.

The Results of Long-Term Observation

There are no long-time results available for penile augmentation. In addition, the surgical outcomes may be affected depending on the surgical procedures, the preoperative diagnosis, and the psychiatric evaluation of patient expectations in addition to the surgeon's skill.

In 30 patients who underwent the autologous dermofat graft performed by the author, after postoperative observation for average of 34.8 months (3–57 months), as the changes of penile girth and length were from 7.44 ± 1.75 cm and 6.72 ± 2.10 cm, respectively, they had shown increases by 24.3 % and 43 % immediately after the surgery and by 18 % and 7.9 % at the last observation, respectively. Those who had shown postoperative satisfaction in the patients and their sex partners at the immediate postoperative period were 16 patients (88.9 %) and 12 patients (66.7 %), respectively, whereas at final observation, they were 13 patients (72.2 %) and 11 patients (61.1 %), respectively. The reasons for dissatisfaction presented by the patients at the final observation included the scar at the graft recipient site shown in three cases (16.7 %) and the size reduction in two cases (11.1 %).

Conclusion

If the penile augmentation using autologous dermofat graft is performed after acquiring sufficient surgical skill, it can be no longer denied by urologists for its medical feasibility as conventional procedures likely to be attempted for the purpose of penile augmentation. However, it should be noted that the surgeon must accurately determine the consistency of the surgical outcomes to the expectation level of patients themselves as well as any accompaniment of psychiatric disorder. Furthermore, the surgeon must

sufficiently explain the surgical procedures, possible complications, and even surgical outcomes including failure for full understanding of patients.

So if the surgeon performs the procedures while keeping such cautions in mind for the penile augmentation surgery, the patients may overcome mental complex due to the size of the penis and shall be given an opportunity to return to the normal life including sexual and social life. And it is expected that such procedures may provide the surgeons who conduct them an opportunity for development of a new medical care region.

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Penile Girth Enhancement with Autologous Fat Transfer

9

Seung Wook Lee and Woong Hee Lee

Introduction

Currently, augmentative phalloplasty is a highly controversial issue. The lack of guidelines for augmentative phalloplasty and the deficiency of evidence-based studies fuel this controversy. Penile enlargement surgery is mainly divided into penile lengthening and penile girth enhancement (PGE). Penile lengthening includes abdomino/pubopelvic liposuction, suspensory ligament dissection, and skin flap construction [1]. Penile girth enhancement uses graft procedures or injection of materials such as autologous fat, silicon, or hyaluronic acid gel [2].

Liposuction is an invasive technique performed to remove subcutaneous fat using suction cannulas [3, 4]. This technique can be utilized to esthetically improve body contouring and harvest fat grafts to be used in reconstructive surgery to repair body deformities resulting from lipodystrophy, burns, trauma, and tumor resection [4, 5]. Autologous fat can manipulate penile girth enhancement using liposuction technique.

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Penile autologous fat injection (AFI) enhances penile circumference via the injection of fat into the penile dartos layer. Panfilov [6] reported that AFI for PGE in the normal-sized penis was effective and safe. Panfilov conducted AFI for PGE and reported that the penile circumference increased by an average of 2.6 cm when 40–68 mL of autologous fat was injected into the penis. In the current study, when 23–49 mL of fat was injected, the penile circumference increased by 2.71 cm, a result similar to that in the study conducted by Panfilov.

The difference between this study and previous studies was that the proximal one third and distal one third of the penis were used rather than the penile midshaft in the measurement of penile girth.

Surgical Technique of Harvesting Autologous Fat with Liposuction

Abdominal/Thigh Fat Suction (Harvesting Autologous Fat)

Before the surgery was performed, the patient's weight and site of fat suction were examined, and a lift test or pinch test was conducted to examine skin elasticity and thickness. The degree of fat accumulation at the surgery site was examined with the patient in the supine position, and then body mapping was conducted at the site of fat suction.

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With the patient under propofol anesthesia, the bilateral inguinal area was incised approximately 0.5–0.7 cm, and tumescent formula (modified Klein's solution) was injected into the subcutaneous fat layer for fat suction (lower abdomen or bilateral thighs) using an infiltrator cannula (diameter, 2 mm; length, 40 cm). The tumescent formula was prepared by dissolving 40 mL of 2 % lidocaine (800 mg), 1 mL of epinephrine (1:1,000), and 20 mL of 8.4 % sodium bicarbonate (1.68 g) in 1 L of normal saline. An amount of this formula one- to twofold larger than the volume of fat suctioned then was injected. The volumes of tumescent formula injected were 400–600 mL in the lower abdomen and 200–300 mL in the thigh. The maximum amount of injected lidocaine did not exceed 35 mg/kg. A harvesting cannula (diameter, 4 mm; length, 47 cm) was inserted into the subcutaneous fat layer via the incised window 15–20 min after injection of the tumescent formula, and then fat suction was performed in a fanlike pattern by moving the harvesting cannula back and forth (Fig. 9.1a, b). Fat was suctioned using a suction pump-assisted liposuction apparatus (Dominant 50, Medela AG, Baar, Switzerland) (Fig. 9.1c).

Fat Preparation

After fat suction, the collected fat in the collection jar of a suction pump-assisted liposuction apparatus was leached out to a fat sieve. The fat sieve is a special tool that can quickly and effectively filter the tumescent solution, blood, and free oil, which are unnecessary fluids during fat suction. Filtered fat should be washed using normal saline (500 mL) to remove unnecessary components once more. After that, the filtered fat tissue was divided into 10-mL syringes using a teaspoon. The capped sampling syringes without the piston were sealed and centrifuged at 3,000 rpm for 3 min (HA 12, Hanil Science Industrial Co. Ltd., Incheon, Korea).

After centrifugation, the harvested fat was separated into three layers. The uppermost layer composed of oil was decanted, and the reddish layer at the bottom composed of blood, water, lidocaine, and fibrous tissue was drained by opening the cap of the syringe. The middle layer composed predominantly of fat was used for the injection.

Penile Autologous Fat Injection

The purified fat was transferred to a 1-mL syringe with a Luer-Lock tip (Becton Dickinson, Franklin Lakes, NJ, USA) connected to an 18-gauge blunt-tip cannula to prevent tissue injury during injection. A penile nerve block was implemented, and the penile skin then was punctured using a sharp needle. A blunt-tip cannula for fat injection was inserted into the Colles' fascia layer, and 1 mL of fat was injected slowly by moving the cannula back and forth (Fig. 9.2).

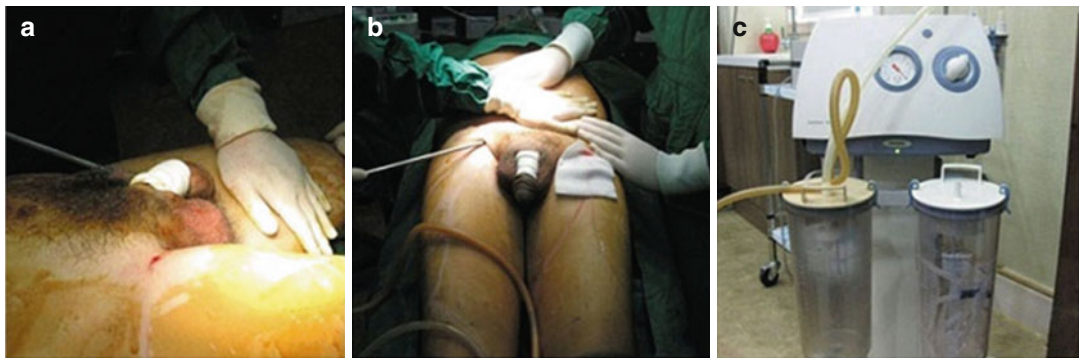

Fig. 9.1 Penile girth enhancement by autologous fat injection. (**a**) Thigh and/or (**b**) abdominal fat suction was performed in a fanlike pattern by moving the harvesting cannula back and forth. (**c**) Fat suction was performed using a suction pump-assisted liposuction apparatus (Dominant 50, Medela AG, Baar, Switzerland)

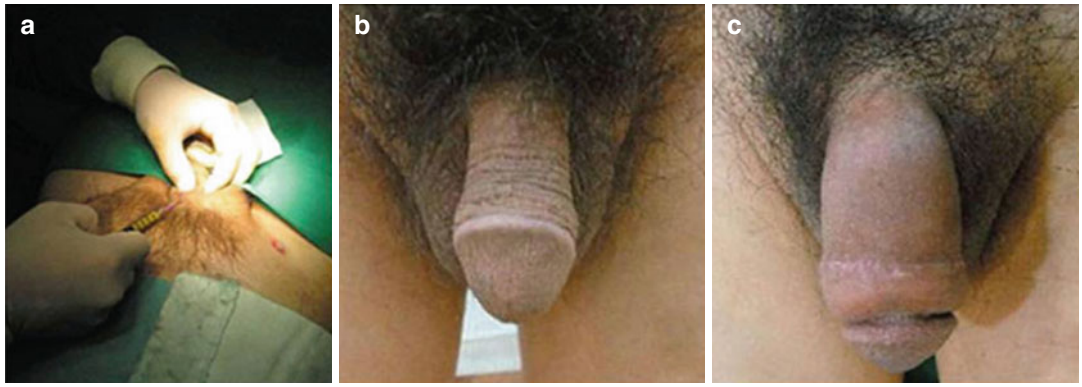

Fig. 9.2 (**a**) An 18-gauge blunt-tip cannula for fat injection was inserted into the Colles' fascia layer, and 1 mL of fat was slowly and evenly injected into the superficial, middle, and deep layers of the Colles' fascia by moving the cannula back and forth. (**b**) Dorsal view of the penis preoperatively. (**c**) Dorsal view of the penis 6 months postoperatively

The fat was evenly injected by inserting the cannula into the superficial, middle, and deep layers of the Colles' fascia. To avoid fat accumulation at one site, five to seven different routes for fat injection were secured at each puncture site, and fat injection was performed in the same manner for each route. The penile skin was punctured at the 11, 1, 3, and 9 o'clock locations around the penis, and the fat was injected into the various layers and directions, with avoidance of the urethral area (5–7 o'clock). Fat was injected throughout the penis, beginning from the distal portion and proceeding to the penile root. Any remaining fat after completion of the injections was transferred to a 10-mL syringe and aseptically stored in a freezer after labeling with patient information.

Autologous Fat Transfer: Complication and Management

As for penile girth enhancement surgery, the need for a simple procedure with minimal donor site morbidity or none at all has led to proposing injection therapy, whether by fat or synthetic materials, intradermally or subcutaneously [7]. Liposuction and subcutaneous injection of fat for augmentation of penile girth have been extensively studied, but its results and adverse effects have been discouraging. Atrophy and reabsorption of the injected fat were commonly issued. This was explained by inadequate uptake of vascularity, difficulty in immobilization of the injected part, and fat cell trauma upon sexual activity. Reabsorption and migration of the injected fat have caused loss of the augmented girth as well as severe deformities and asymmetry.

The transplanted fat is revascularized in the centripetal manner. Its capacity to survive through the plasmatic imbibitions from the edges is 0.5 to 1.5 mm. Thus, the single threads of the transplanted adipose tissue should not exceed 3 mm in diameter. The larger single collections of fat are subject to liquification, central necrosis, and cyst formation. This, in addition to technical imperfections, was the reason for reports of remarkable resorption rates and general unpredictability of the results [8].

Complications

Meanwhile, the penile shaft is a totally different matter compared with the augmentation of limited volume and compact tissue planes. The penile shaft is formed of concentric layers: Buck's fascia, Dartos muscle, and skin, thereby forming multiple and relatively wide facial planes along in which injected filler materials may migrate. Penile erection causes alternation between tumescence and detumescence, preventing the immobilization necessary for a

Fig. 9.3 Distal shaft fat injection result in asymmetric right side nodule (4 years follow-up)

homogenous and predictable tissue reaction. Moreover, sexual intercourse will only aggravate the problem of migration, squeezing the injected material distally and proximally [9].

Nowadays, diverse synthetic materials are available for girth enhancement and sometimes mixed injected with fat and synthetic materials is revealed at excision specimen. In those cases, tissue reaction to the injected material may be excessive and heterogeneous, leading to the formation of an irregular foreign body granuloma.

Girth augmentation procedures may be complicated by nodule formation due to uneven fat resorption or a deformed appearance related to irregular fatty lumps over the penis. Therefore, the main reasons for dissatisfaction were poor cosmetic appearance related to irregular residual fat nodules leading to shaft deformities, loss of injected fat, and penile skin deformity. Fortunately, autologous fat injection does not show disastrous complications such as extensive preputial skin necrosis involving graft failure which requires skin graft that even results in functional sequelae of erectile dysfunction. However, atrophy and reabsorption of the injected fat by inadequate uptake of vascularity commonly occurs after several months [10] (Figs. 9.3, 9.4, and 9.5).

Fig. 9.4 Distal ventral fat injection result in lump formation with fat resorption (5 years follow-up)

Fig. 9.5 Large amount fat injection results in poor cosmetic appearance of irregular fat nodules leading to shaft deformity and sagging of preputial skin (8 years follow-up)

Management

More delayed complications are asymmetricity and deformed nodules. Some practitioners perform redo autologous fat injection procedures for correcting the irregularity of augmented results, but repeated subcutaneous injection of fat for augmentation does not always result in success as expected.

At this point, an important aspect that needs to be considered is that proximal penile shaft shows somewhat difference in fascial anatomical space which contains more room and relatively loose concentric fascial layers among

Buck's fascia, dartos muscle, and skin. Therefore, repeated fat injection may not achieve long-term results of successful correction of irregularity. Unsatisfactory results of fat injection should rather be corrected situationally with careful removal of injected fat totally or partially. For cases presenting with postinjection complications requiring surgical intervention, meticulous surgical technique is essential considering that the overlying skin may be adherent and thinned out, possibly ending in avascular necrosis. Therefore, sparing a thin safety margin of the fibrous tissue capsule adherent to the skin is recommended to preserve vascular supply [11].

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Classification of Soft Tissue Filler

10

Won Ki Lee and Dae Yul Yang

Introduction

The need for safe, effective, and less invasive procedures is increasing in recent years through all fields of modern medicine. This trend is evident especially in aesthetic medicine including soft tissue augmentation. As aesthetic procedures are almost always performed by the patient's needs, consideration on the ratio of benefits to risks is very important and leads patient and physician to prefer the nonsurgical treatment. Furthermore, different kinds of nonsurgical procedures have been introduced in the past decade. According to the data from the American Society for Aesthetic Plastic Surgery (ASAPS), nonsurgical procedures increased 521 % from 1997 to 2013, whereas surgical procedures only increased 89 % during the same period in the United States.

Soft tissue fillers are one of the mainstay treatments for nonsurgical treatment of soft tissue augmentation. According to the data from the American Society of Plastic Surgeons (ASPS), soft tissue filler treatments are the second most popular nonsurgical treatment in the United States, with over 2.2 million procedures performed in 2013. Within the last decade, the popularity of soft tissue fillers has grown rapidly, because treatments with soft tissue filler are generally safe, effective, less invasive, and less expensive than most surgical treatments [1]. Currently, over 200 products are available worldwide from more than 50 companies [2, 3] (Table 10.1).

The first filler for soft tissue augmentation was autologous fat, which was described in the late nineteenth century. Since then, many different techniques have evolved for fat harvest and transfer and are now used widely for soft tissue augmentation [4]. The first reported use of soft tissue filler for cosmetic purposes was by Robert Gersuny. In 1899, he first introduced paraffin for soft tissue augmentation, which eventually became a common filler material for a few years. But the paraffin is no longer used, as the high incidence of severe complication became evident [4]. Silicone was first used for breast augmentation in the 1940s. Silicone is still used for soft tissue augmentation in some countries, although serious complications including death have been reported [4]. Collagen was developed in the early 1970s and approved for cosmetic use in the United States in 1981. Since then, collagen was the only commercially available product in the United States for 22 years. Collagen-based products are still used widely for soft tissue augmentation [2]. In the early twenty-first century,

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Table 10.1 Partial list of commercially available soft tissue fillers [2, 3]

Key component	Product trade name	Manufacturer
Hyaluronic acid	Restylane	Q-Med/Medicis/Galderma
	Captique	Genzyme/Inamed
	Juvederm	Inamed/Allergan
	Hylaform	Biomatrix
	Belotero	Merz pharmaceuticals
	Varioderm	Adoderm GmbH/Medical Aesthetics group
	Emervel	Galderma
	Teosyal	Lifestyle Aesthetics/TEOXANE Laboratories
	HydraFill	Allergan
	Surgiderm	Allergan
	Hyaluderm	LCA Pharmaceutical
	STYLAGE	VIVACY Laboratories
	Perlane	Medicis Aesthetics
Human collagen	Cosmoderm	Inamed/Allergan
	Cosmoplast	Inamed/Allergan
Bovine collagen	Zyderm	Inamed corporation
	Zyplast	Inamed corporation
Porcine collagen	Evolence	ColBar LifeScience
Poly-L-lactic acid	Sculptra	Dermik Aesthetic
Calcium hydroxyapatite	Radiesse	Merz Aesthetics
Polymethylmethacrylate	Artecoll	Rofil Medical
	Artefill	Artes Medical
	Lipen	Chunghwa Medipower
Polyacrylamide	Aquamid	Contura International
	Outline	Trillium Meditec
Silicone	Bioplastique	Uroplasty
	Silikon-1000	Alcon

the introduction of several innovative synthetic fillers was a turning point in the advancement of soft tissue augmentation. Hyaluronic acid (HA) was approved by the US Food and Drug Administration (FDA) in 2003. Poly-L-lactic acid (PLLA) was approved in 2004. Polymethylmethacrylate (PMMA) and calcium hydroxyapatite (CaHA) were approved in 2006. Autologous fibroblast was approved in 2011. Various forms of these materials have been developed for soft tissue augmentation and have led to a boom in popularity of synthetic fillers.

Although various filler materials and products have been introduced and are currently available, the ideal filler has not yet emerged. The ideal soft tissue filler should be biocompatible, safe, and stable at the implanted location. It should keep its volume and remain pliable. Also, it should induce minimal foreign body reaction including granuloma formation, not be removed by phagocytosis, and not have migration potential to other locations [5]. The characteristics of ideal soft tissue fillers are presented in Table 10.2.

To perform the penile augmentation using filling agents reasonably, it is essential to understand the penile anatomy. Corporal bodies of penis are surrounded by tunica albuginea, deep fascia (Buck's fascia), superficial fascia (dartos fascia), and the skin [9] (Fig. 10.1). The skin is devoid of fat and is highly elastic and quite mobile. The dartos fascia (red line of Fig. 10.1) lies below the skin, which places it superficial to Buck's fascia. It is also continuous with Colles' fascia of the perineum and Scarpa's fascia of the abdomen.

Table 10.2 Some of the characteristics of ideal soft tissue fillers [5–8]

Aspects	Characteristics
Material	Biocompatible
	Nonantigenic
	Nontoxic
	Noncarcinogenic
	Nonteratogenic
Performance	Reproducible outcome
	Consistent outcome
	Adequate duration of augmented volume
	Pliability
	High safety
	Minimal foreign body reaction
	Minimal migration from the implanted location
Technique	Ease of administration
	Suitable formulation to facilitate adequate placement
	Stable formulation to facilitate handling
Subjective satisfaction	Predictable outcome
	Minimal adverse experiences
	Minimal downtime
Others	Approval by the professional societies or governments
	Versatile across applications
	Affordable and/or inexpensive
	Reversible

Buck's fascia (blue line of Fig. 10.1) is a tenacious and dense layer of deep fascia, covering the corporal bodies. It is also continuous with the suspensory ligament of the penis and the external spermatic fascia in the scrotum. It covers the dorsal arteries, deep dorsal veins, and nerves. Tunica albuginea (black line of Fig. 10.1) encloses the corpus cavernosum. Its inner circular and outer longitudinal fibers form an undulating meshwork when the penis is flaccid and appear tightly stretched with erection. Injection of filler materials under Buck's fascia has a potential to cause threatening side effects such as vascular and nerve injuries, or emboli. It may not have enough space between dartos fascia and skin to fill the filler materials for augmentation. For these reasons, the filler materials are commonly injected between dartos fascia and Buck's fascia. The loose attachment of the dartos fascia to Buck's fascia provides enough space to fill the filler materials and does not affect the high degree of mobility of the penile skin over the underlying tissue. Furthermore, a tenacious, dense, and whitish layer of Buck's fascia is appropriate for landmark of injected site and facilitates ease of procedure.

Understanding the different capabilities, characteristics, and risks of filler materials is essential for physicians to counsel with patients, to achieve the desired outcomes, to reduce the risk of adverse events, and to treat the complications. Soft tissue fillers can be classified in various ways, such as the source of filler material or duration of result [6, 10, 11] (Table 10.3). The duration of result is most commonly used, among different classifications. Based on duration of results, fillers can be divided into nonpermanent, semipermanent and permanent categories. Nonpermanent fillers typically have a short (less than 3 months) or medium duration (3–12 months). As these are generally reabsorbed within a year, repeated procedures may be needed for long-term outcomes. Collagen and HA are typical examples of nonpermanent filler. Semipermanent fillers have a long duration (several years), but can be expected to be partially reabsorbed as well. PLLA and CaHA are typical examples of semipermanent filler. Permanent fillers are basically non-resorbable and can be expected to cause long-term outcomes with a single procedure. PMMA and polyacrylamide are typical examples of permanent filler.

Various filler materials and products are currently available in the marketplace. Also, new filler materials and products are still emerging. Some of them have proven the acceptable safety and effectiveness, and others have not. It is remarkable that clinical evidence regarding soft tissue fillers in the field of penile augmentation is relatively lacking, and most of soft tissue fillers are not approved yet by the professional societies or governments. However, almost all existing fillers have a potential to be used for penile augmentation, and some of them have been widely used in real practice, regardless of scientific data. In this chapter, commonly used soft tissue fillers will be discussed according to the composition, characteristics, and risks (Table 10.4).

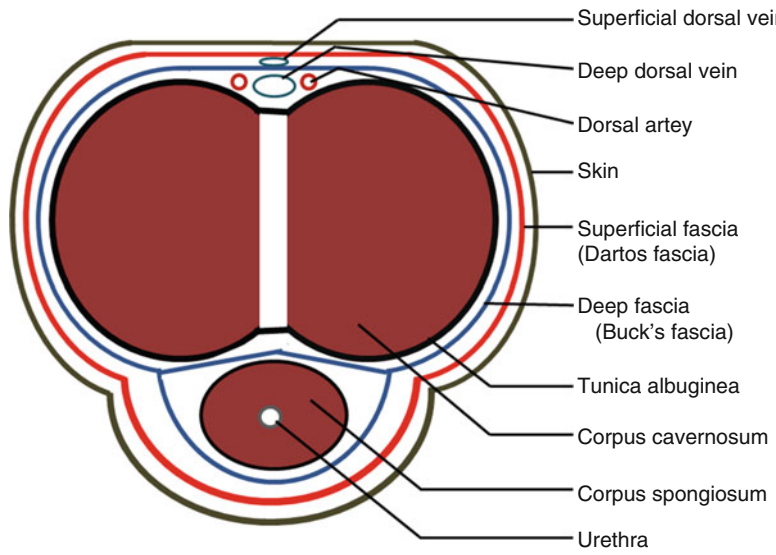

Fig. 10.1 Schematic view of penile anatomy (cross section at penile shaft), demonstrating the relationship between the penile fascia and corporal bodies. The filler materials are commonly injected between dartos fascia [*red line]* and Buck's fascia [*blue line*]. The loose attachment of the dartos fascia to Buck's fascia provides enough space to fill the filler materials and does not affect the high degree of mobility of the penile skin over the underlying tissue. Furthermore, a tenacious, dense, and whitish layer of Buck's fascia is appropriate for landmark of injected site and facilitates ease of procedure

Table 10.3 The potential classification of soft tissue fillers [6, 10, 11]

Method of classification	Subclassification	Typical examples of filler materials
Duration of result	Nonpermanent Semipermanent Permanent	Collagen, hyaluronic acid
		Poly-L-lactic acid, calcium hydroxyapatite, hyaluronic acid
		Polymethylmethacrylate, polyacrylamide, silicone
Source of filler materials	Autologous Biological Synthetic	Fat
		Collagen, hyaluronic acid
		Poly-L-lactic acid, calcium hydroxyapatite, polymethylmethacrylate, polyacrylamide, silicone
Difficulty of the procedure	Low Medium High	Saline
		Collagen, hyaluronic acid
		Fat, poly-L-lactic acid, calcium hydroxyapatite, polymethylmethacrylate, polyacrylamide, silicone

Classifications are somewhat relative and can be affected by a specific product

Autologous Fat

Autologous fat is usually harvested from the abdomen, buttock, or thigh. It was initially thought as a promising filling agent, as readily available, relatively inexpensive, and abundant substance without immunologic rejection. However, during the injection process, a significant number of adipocytes are ruptured or reabsorbed, and probably the final result leaves only 10–30 % of the fat cells intact [2, 15]. Furthermore, autologous fat is considered as unpredictable

Table 10.4 Characteristics of commonly used soft tissue fillers [3, 7, 10, 12–14]

Filler	Duration	Pros	Cons
Autologous fat	A few month, up to 10 years	Unnecessary allergy test Immediate effect Abundant substance Easy availability Inexpensive property Safety	Unpredictable outcome Donor site morbidity
Collagen	2–6 months, up to 12 months	Immediate effect Easy administration Safety	Short-lasting effect Necessary allergy test (bovine based)
Hyaluronic acid	4–6 months, up to 18 months	Unnecessary allergy test Immediate effect Reversal with hyaluronidase Safety	No biostimulatory property Possible bluish discoloration
Silicone	Permanent	Long-lasting effect Long clinical experience Unnecessary allergy test	Concern about safety Technically difficult removal
Poly-L-lactic acid	1–2 years, up to 3 years	Unnecessary allergy test Biostimulatory property	No immediate effect Requisite several sessions Non-reversibility Radiopaque property
Polymethylmethacrylate	May be permanent	Long-lasting effect	Necessary allergy test (for bovine collagen component)
Calcium hydroxyapatite	10–18 months, up to 3 years	Unnecessary allergy test Immediate effect Biostimulatory property	Non-reversibility Radiopaque property
Polyacrylamide	May be permanent	Long-lasting effect Unnecessary allergy test	Concern about granuloma formation Concern about infection

Characteristics of fillers are somewhat relative and can be affected by a specific product

filler, due to the lack of adequate blood supply to the injected fat and because the plane into which the adipocytes are injected has not been determined [16]. Autologous fats at injected site remain stable usually for a few months, but up to 10 years. Recent advancements of procedures including liposuction techniques seem to provide for longer duration and more predictable outcomes, compared to the past. Currently, adipose-derived stem cells using a stromal vascular fraction are under way, although there is a lack of clinical evidence for soft tissue augmentation [17].

Reabsorption or migration can cause the penile curvature or asymmetry, nodule, or calcification. Rarely, sclerosing lipogranuloma may occur. Large amounts of injected fat have a potential to increase the risk of complications.

In the field of penile augmentation, Panflov reported that the penile circumference increased by 1.4–4.0 cm (mean 2.65 cm) when 40–68 mL of autologous fat was injected in 88 subjects [18]. Kang and colleagues investigated 52 patients who were followed up for more than 6 months [19]. They reported that the penile circumference increased a mean of 2.71 cm with 23–49 mL of autologous fat injection, and the only complication was a fat nodule in one patient.

Collagen

Endogenous collagens are the structural base of the skin, providing strength and support. Collagen-based filler was developed as a replacement for endogenous collagens. It was the only commercially available product in the United States, from 1981 to 2003. And it still remains a standard by which new fillers are often compared

[1]. Rapid degradation leading to frequent reinjection and irregular outcomes are major weaknesses of collagen, although collagen-based products are still used widely for soft tissue augmentation [2].

To produce effects of collagen for soft tissue augmentation, volume displacement immediately appears after injection. During degradation, collagen increased fibroblast infiltration and vascularization. Fibroblasts provoke an inflammatory response, leading to new collagen bundles in parallel array along new small blood vessels (called collagen neogenesis) [20]. Inflammation with subsequent edema may lead to some of the augmentation [12].

Today, commercially available collagen-based products are derived from bovine, human, and porcine. The effect of bovine collagen generally lasts 2–6 months. One of its major drawbacks is a potential to produce infrequent but significant hypersensitivity reactions. It is estimated that hypersensitivity reactions will occur in approximately 3 % of individuals [21]. Therefore, allergy testing via skin inoculation is required before injection. Allergy testing is generally recommended to perform twice, administered 2 weeks apart, followed by observation for 2–4 weeks [1]. Hypersensitivity reactions may be treated with corticosteroid, cyclosporine, or tacrolimus [22]. Other potential adverse events of bovine collagen include nodules, beading, and rarely granulomatous reactions [1]. Human collagen filler is derived from human fibroblasts. Consequently, allergy testing is not needed. However, it has a relatively short duration of effect, similar to that of bovine collagen filler. Adverse events are rare and commonly limited to injection site reactions [21]. Porcine collagen filler (brand name Evolence) is derived from the pig gastrocnemius tendon and was approved by the FDA in 2008. It is believed to last for at least 6 months up to 12 months [23]. During manufacturing process, N-terminals, which are associated with immunologic reaction, were removed from collagen. Consequently, Evolence closely resembles human collagen and decreases immunogenicity [24]. Adverse events are mostly mild and are commonly limited to injection site reactions [25].

Hyaluronic Acid

It is no exaggeration to say that the modern era of synthetic selective bioactive filler began with HA-based fillers. These have led to a boom in popularity of soft tissue fillers. According to the 2013 ASAPS statistics, HA-based fillers were the most commonly used soft tissue filler in United States.

HA is a naturally occurring hygroscopic polysaccharide in the extracellular matrix, composed of repeating disaccharides units of N-acetylglucosamine and D-glucuronic acid. Chains of glycosaminoglycan coil on themselves, leading to an elastic and viscous matrix. As HA is an important natural component of human skin and is a conserved component throughout all living organisms, HA-based fillers do not possess species or tissue specificity. Therefore, humoral or cell-mediated immune reactions are extremely rare, and allergy test is not needed. HA is stored without refrigeration for up to 2 years, as its molecule is relatively stable. Additionally, HA serves to hydrate the skin due to its extremely hydrophilic nature [26].

HA-based products are derived from different forms. For example, Restylane, Captique, and Juvederm are non-animal in origin, formed through streptococcal fermentation of sugar. And hylaform is xenogenic from rooster combs. Non-animal-derived HA-based products are believed to cause less immune reaction, compared to xenogenic HA-based products [27]. Currently, non-animal-derived HA-based fillers are more commonly used than others. Meanwhile, HA-based products can be classified as mono- or biphasic filler. Monophasic filler is an entirely stabilized smooth gel without particles. Biphasic filler is a gel with particles of cross-linked HA suspended in a liquid. A pilot study showed that durability of monophasic fillers seems to be superior to that of biphasic fillers [28].

The half-life of HA in natural form is within 20 h, and HA lasts only 1–2 days [29]. Cross-linking process is used to stabilize HA, leading to an increased longevity. One of the significant differences between the various HA-based products is the amount of molecular cross-linking. In theory, more cross-linking causes more increased longev-

ity. However, in practice, the amount of cross-linking does not entirely correlated with longevity [26]. Although HA-based fillers generally last 4–6 months after injection, recently developed products have shown long-lasting efficacy of up to 18 months. After injection of HA, it is gradually absorbed and disappears by the surrounding tissue. During degradation, as molecules bind more water, the same volume can be maintained with less HA (called isovolemic degradation) [30]. Theoretically, more than 95 % of its initial volume is maintained until HA is completely absorbed [31].

Adverse events are mostly injection related and transient. Most common adverse event is hypersensitivity reactions (approximately 0.02 %) [32], and major adverse events include infection, granulomatous reaction, and formation of acneiform and cystic lesions [33]. Superficial injection may leave a bluish discoloration (called *Tyndall effect*). However, serious adverse events are rare. Some of the adverse events or migration may be safely reversed with hyaluronidase [34].

In the field of penile augmentation, Kwak and colleagues investigated 41 patients who were injected with a mean of 20.56 mL and followed up for 18 months [35]. They reported that the increase in the circumference of girth has a mean of 3.9 ± cm (3.4–4.4) at 1 month and significantly decreased to 3.8 ± 0.3 cm (3.2–4.2) at 18 months. There was no deformity with erection compared with the flaccid state and were no signs of inflammation and no serious adverse reactions in all cases. Kim and colleagues investigated 41 patients who were injected with a mean 2 cm^3 into their glans penis [36]. They reported that the increase in glandular circumference was 1.5 cm at 1-year follow-up, and there were no sign of inflammation and no serious adverse reactions in all cases. The same investigators also reported results at 5-year follow-up, showing an only 15 % decrease in glandular circumference [37].

Silicone

Silicone is the generic term encompassing a family of man-made polymers containing elemental silicon (Si) [38]. Medical-grade silicone, which is derived from silica and composed of polymerized dimethylsiloxane, is an inert, clear, oily liquid [29]. Liquid injectable silicone (LIS), or polydimethylsiloxane, has been widely used for soft tissue augmentation for at least 40 years, and it was the soft tissue filler of choice before collagen fillers were introduced in the early 1980s [39]. However, debate regarding the safety of LIS has emerged over the past three decades, and its use still remains controversial.

LIS is injected using a microdroplet technique. After injection of LIS, volume displacement immediately appears. And then, granuloma formation and local fibrosis were induced as it is unable to be phagocytized by macrophages [24]. At 1 month, it is observed that each microdroplet is encapsulated by collagen and fibroblasts. From 3 to 6 months, macrophages and giant cells additionally surround the microdroplets. At 9 months, granulomatous nodules are observed around the microdroplets [24]. At 14 months, an intense fibrosis can be present [7].

LIS is distinctive among the soft tissue fillers with regard to its permanence and is generally regarded as permanent filler. However, the permanence of LIS does not guarantee the permanent aesthetic results, because of continued tissue volume loss induced by LIS.

Common adverse events include edema at injection site, erythema, and ecchymosis and usually resolve within a few days. LIS has a potential to migrate other sites, and its possibility seems to be associated with the amounts of injected LIS [38]. Skin dyschromia, which is a rare adverse event, occurs often when LIS is inadvertently injected into the dermis. The most worrisome potential adverse event is granuloma formation. It is considered to be immune mediated, but its exact mechanisms are unclear [38]. It is estimated that some fraction of 1 % of patients correctly treated with LIS may eventually develop this reaction [40]. LIS can gradually harden and may form a granuloma or "late siliconoma." These can generally be treated with steroid injection or antimitotic agents and may require surgical removal [7, 38].

As previously described, the use of LIS still remains controversial. Proponents argue that LIS

is safe if some rules are observed: (1) use of highly purified approved product, (2) employment of microdroplet serial puncture technique, and (3) use of small volume with up to 2 mL at each session with multiple sessions [33]. Opponents argue that serious adverse events are common and unpredictable, in spite of the use of proper techniques and products [33].

In the field of penile augmentation, it seems to be desired that LIS is not recommended at present [41]. Some of the horrendous adverse events are often related to the large amounts of LIS. Considering that large amounts of LIS are generally needed to perform the penile augmentation, the use of LIS does not seem to be appropriate. In addition, LIS may cause loss of penile sensation and erectile dysfunction. There are few studies about the injection of LIS for penile augmentation, and most of them concern patients presenting with adverse events. Interestingly, there is only study that showed the encouraging results about the use of LIS [42]. Yacobi and colleagues investigated 324 patients who were injected with a mean 5 mL and followed up for a mean of 20 months (range 1–36 months). They reported that the increase in the circumference of girth has a mean of 2.6 cm. There were no serious adverse reactions in all cases. Although their results are interesting, longer-term follow-up is needed to prove the safety of LIS.

Poly-L-Lactic Acid

PLLA is a biodegradable, resorbable synthetic polymer which belongs chemically to the alpha-hydroxy-acid group [13]. PLLA filler consists of microparticles, measuring an average of 40–63 μm in diameters, of PLLA in a sodium carboxymethylcellulose gel [33]. As PLLA filler is manufactured as a powder, it must be reconstituted with sterile water before injection.

PLLA has an ability to stimulate fibroblast proliferation and neocollagenesis by foreign body reaction, which stimulates a cellular inflammatory response [43, 44]. After injection, PLLA filler becomes absorbed over a few days. For months or even years, microparticles of PLLA become surrounded in a connective tissue capsule. And then, microparticles are gradually degraded by hydrolysis, while injected site undergoes subtle volume expansion by a fibrous tissue response with collagen deposition. These bio-stimulatory properties of PLLA filler are one of the main characteristics that differentiate it from other fillers [44]. For example, HA or collagen has a passive and direct effect on augmentation. However, volume-enhancing effect of PLLA is delayed in nature and lasts long after the PLLA is absorbed. Many studies showed that PLLA filler does not produce permanent augmentation, and its effect lasts 2 years up to 3 years. Sometimes, several injection sessions may be required for optimal augmentation.

The risk for allergic reactions or severe adverse events is usually considered low, as PLLA is synthetic and non-animal in origin [45]. Skin allergy testing is not required [1]. Injection-related adverse events such as bruising, hematoma, or edema are common and usually resolve within a week. The formation of papules and nodules is also a common adverse event (<10 %). As these tend to spontaneously resolve within months, expectant treatment is usually performed. If not resolve, intralesional steroid injection or excision may be needed [46]. Hypersensitivity reactions are uncommon, but may result in edema, pruritus, or granuloma formation. Intralesional steroid injection or immune-modulating agents are effective for the treatment [47].

Recently, polylactic-co-glycolic acid (PLGA) is expected to be used for penile augmentation. PLGA is synthesized by ring-opening copolymerization of the cyclic dimers of glycolic acid and lactic acid [48]. As PLGA is a biodegradable and biocompatible polymer, it has been used in various biomedical devices such as grafts, sutures, and implants. In preliminary study about penile augmentation, Lee and colleagues investigated 23 patients who were injected with a mean 10 mL of PLGA-based filler and followed up for 6 months [49]. They reported that the circumference of girth increased by a mean of 2.4 cm. Adverse events were five cases, including three cases of injection site induration, one of penile curvature, and one of painful erection. All adverse

events were mild and improved within several months. There were no clinically significant adverse events in all subjects.

Polymethylmethacrylate

PMMA, which is synthetic polymer of methyl methacrylate, is a non-absorbable, biocompatible, and permanent filler material. It consists of 30–120 μm-sized microspheres with smooth surface. The smooth, electrically uncharged PMMA microspheres are encapsulated by endogenously derived connective tissue, preventing migration of the microspheres [50]. Also, the PMMA microspheres resist phagocytosis and are not degraded by enzymatic digestion [1]. After injection, microspheres bring out foreign body reaction, leading to attraction of macrophage. Microspheres are encapsulated by the macrophages as a monocellular layer and become a uniform network of granulation tissue composed of macrophages, fibroblasts, and collagens [51]. Histologic studies indicate that microspheres are encapsulated by as early as 1 month, and mature connective tissue and vasculature are maintained for over 10 years [7, 51]. PMMA microspheres are theoretically permanent and are only reversed with surgical excision.

PMMA has been used in combination with other compounds [52]. Artefill (Artes Medical, USA), consisting of 20 % PMMA microspheres and 80 % bovine collagen, is well known and widely used [53]. The bovine collagen prevents undesired clumping of PMMA. It is absorbed within 1–3 months after injection and is replaced by the body's own connective tissue over time. One of the major drawbacks is its potential for hypersensitivity reactions, because of the presence of bovine collagen. Artefill requires that all subjects undergo appropriate skin testing. Lipen (Chunghwa Medipower, Korea), consisting of 15 % PMMA microspheres and 75 % cross-linked dextran with 10 % hypromellose solution, is a recently developed soft tissue filler. Cross-linked dextran is derived from dextran used as volume expander and consists of microspheres. Its positive surface charges attract macrophages. In turn, the macrophages release TGF-beta and interleukins, which stimulate fibroblasts to produce collagen fibers. After being extensively reabsorbed, dextran is replaced by the body's own tissue [54]. The injection of Lipen does not need allergy test, as dextran is used instead of bovine collagen.

The most common adverse event is lumpiness, most of which are mild. Other adverse events include erythema, itching, hypertrophic scarring, and granuloma formation. Erythema, itching, and granuloma may require treatment with corticosteroids [7].

In the field of penile augmentation, Yang and colleagues investigated 20 patients who were injected with a mean 24 mL and followed up for 6 months [50]. They reported that the penile circumference increased by a mean of 3.7 cm at penile base, mean of 4.2 cm at midshaft, and mean of 3.8 cm at distal shaft. The complications were only one mild asymmetry of penile shape and one 5 mm-sized nodule in the injected site. There were no clinically significant adverse events in all subjects. The same investigators also reported results at 1-year follow-up, showing no significant difference between 6 and 12 months [55].

Calcium Hydroxyapatite

CaHA, which is a mineral-like compound, is the main component of human bone and teeth. CaHA, which is biosynthetically produced, is nontoxic, non-mutagenic, nonantigenic, and nonirritant and has been used as implant or coating material in orthopedic or dental surgery for over 20 years. Therefore, CaHA does not need allergy test, as it is biocompatible and non-immunogenic.

CaHA filler (Radiesse, Merz Aesthetics, USA) is a biodegradable product, consisting of 30 % CaHA microspheres with particle size of 25–45 μm and 70 % aqueous gel containing carboxymethylcellulose [56, 57]. After injection into soft tissue, CaHA and gel provide immediate volume enhancement. Gel is degraded within 2–3 months, and CaHA microspheres form a scaffold for ingrowth of fibroblasts [13, 58]. Neocollagenesis occurs in and around the microspheres, as the gel

is phagocytized. New collagen fibers prevent the migration of CaHA microspheres. The microspheres are gradually degraded and are broken down to its metabolites, calcium and phosphate ions, which are eliminated through the urinary system, for over several months to years [59]. The increase of new collagen fibers along with the breakdown of CaHA microspheres is understood to explain the slightly decrease in volume [24, 60]. Histologic study revealed that a fine capsule surrounding the microspheres is detected at 3 months after injection, and microspheres start to be absorbed at 9 months [7]. Augmentation effect of CaHA filler lasts 10–18 months, over 3 years. As CaHA-based products are radiopaque, they are plainly visible in radiography [57].

The common adverse events include throbbing pain, erythema, and edema ecchymosis and are usually self-limited. Nodular formations are rare, and most of them resolve within 4–6 weeks [58]. However, if they do not resolve, surgical correction may be needed [13].

Polyacrylamide

Polyacrylamide hydrogel has been used for soft tissue augmentation for the past 20 years. Several products are commercially available and consist of polyacrylamide polymers of different consistencies [61]. Among them, Aquamid (Contura International, Denmark), which is the most popular polyacrylamide hydrogel, consists of 2.5 % cross-linked polyacrylamide and 97.5 % apyrogenic water. It is manufactured by polymerization of the acrylamide monomers and N,N'-methylenebisacrylamide.

Aquamid is considered as biocompatible, nonabsorbable, and permanent filler [2]. However, the interactions of Aquamid with the surrounding tissue have not been well established. One histologic study showed that Aquamid has a bioactivity with cell infiltration and integration into tissue within 8 weeks after injection [62]. However, another study showed that Aquamid remained intact as a formation of fine fibrous capsules at 9 months after injection [5].

Adverse events include inflammation, nodule and granuloma formation, and delayed hypersensitivity reactions. In some cases, surgical excision may be needed. Infection after injection is rare and may be due to bacterial biofilm formation. For this reason, prophylactic antibiotics can be recommended [11].

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Penile Girth Enhancement with Allograft

11

Gyung-woo Jung

Introduction

Allograft is an acellular dermal matrix (ADM), which is available in sheets. ADM is acquired from donated skin using proprietary processing techniques that are reported to preserve the biochemical and structural components of the extracellular matrix (ECM). This promotes tissue regeneration. Human ADM is extremely useful in burn care [1] and reconstructive surgery, such as breast reconstruction [2], abdominal hernia repair [3, 4], and cleft palate repair [5]. In addition, ADM graft can be combined with autologous thin split-thickness skin graft for safe and effective reconstructive procedures [6].

Various allografts have been used in penile augmentation: AlloDerm® (LifeCell Laboratories, USA), MegaDerm® (L&C BIO, Korea), and SureDerm® (Hans Biomed, Korea). AlloDerm® grafting has been sporadically reported for penile girth procedures [7]. The use of AlloDerm® for penile girth enhancement has a more consistent cosmetic result with respect to penile symmetry and durability compared with that of dermal fat grafting [8]. The advantages of allografting include no donor-site scarring [9], good graft survival, and a low complication rate [7]. However, the viability of the overlying thin and delicate penile skin can be compromised in this procedure [10].

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Allograft Materials

MegaDerm® (L&C BIO, Korea) is derived from donated human skin supplied by US tissue banks under the guideline of the American Association of Tissue Banks (AATB) and US Food and Drug Administration (FDA). It has been used as a dermal implant and filler in various reconstructive procedures (e.g., facial augmentation, breast reconstruction) and after thyroidectomy, and parotidectomy, in Korea. Epidermal and dermal cells were removed without damage to essential biochemical and structural components including collagen, elastin, and proteoglycans. The remaining acellular, dermal layer was preserved by using a proprietary freeze-drying method, which retains the native extracellular architecture and vascular channels. MegaDerm® is packaged in this freeze-dried form and can be stored up to 5 years. E-beam irradiation was used to cross-link collagen and eliminate viruses, bacteria, and spores to achieve a sterility assurance level of 10^{-6} [11].

In animal study [11], the MegaDerm® implants exhibited mild inflammation with cellular infiltration and ECM deposition. A small amount of loosely organized collagen and elastin

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fibers were present within the MegaDerm® before implantation. However, collagen and elastin fibers became more abundant with time, and the porous architecture of the MegaDerm® was replaced by new collagen and elastin fibers after 6 months (Fig. 11.1). MegaDerm® allows adequate tissue ingrowth, provides long-term structural integrity, and results in prolonged remodeling. These characteristics suggest that MegaDerm® is a suitable implant for soft tissue augmentation procedures such as facial augmentation, abdominal hernia correction, and breast augmentation. In addition, MegaDerm® could provide elasticity, flexibility, and strength to the dermis after skin autograft surgery [12].

Tissue Preparation

At the beginning of the operation, the allograft is soaked in normal saline with antibiotics for at least 20 min before grafting. Once hydrated, the thin sheet attached to one side of the AlloDerm® is removed (MegaDerm® has no thin sheet), and blood is applied to both sides of the allograft. It is then washed with normal saline, which will result in blood remaining on only one side (Fig. 11.2). The blood-remained side should be faced Buck's fascia side. The width of the allograft is determined by measuring the circumference of both corpus cavernosa without extending into the corpus spongiosum, and the length of the allograft is

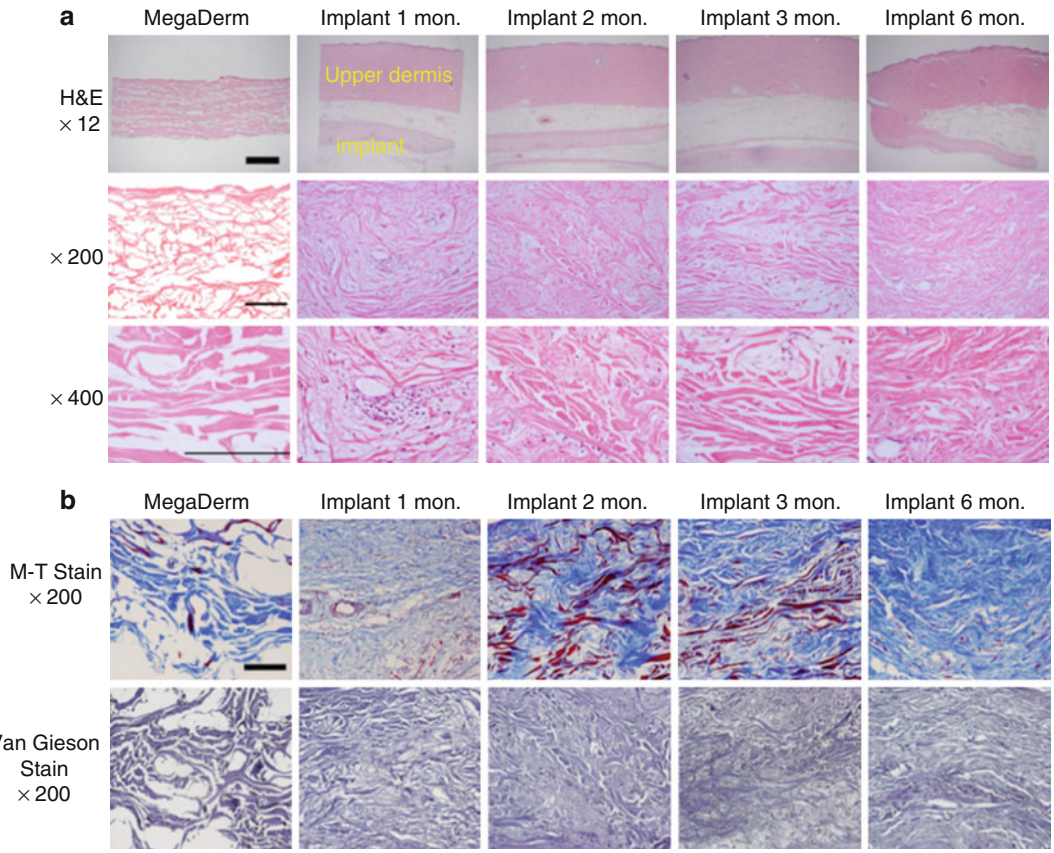

Fig. 11.1 Histologic analysis of implanted MegaDerm®. (**a**) H&E staining of the implanted cross-linked MegaDerm® showed that the porous architecture was replaced by host tissue ingrowth and cellular infiltration over time (×200, scale bar = 2 mm). (**b**) Deposition of collagen and elastin fiber also increased over time. Collagen fibers became denser and thicker with time (Masson's trichrome stain), and collagen fibers became more abundant and irregular, consistent with healthy connective tissue. Elastin fibers increased at 6 months after implantation (Verhoeff-van Gieson stain)

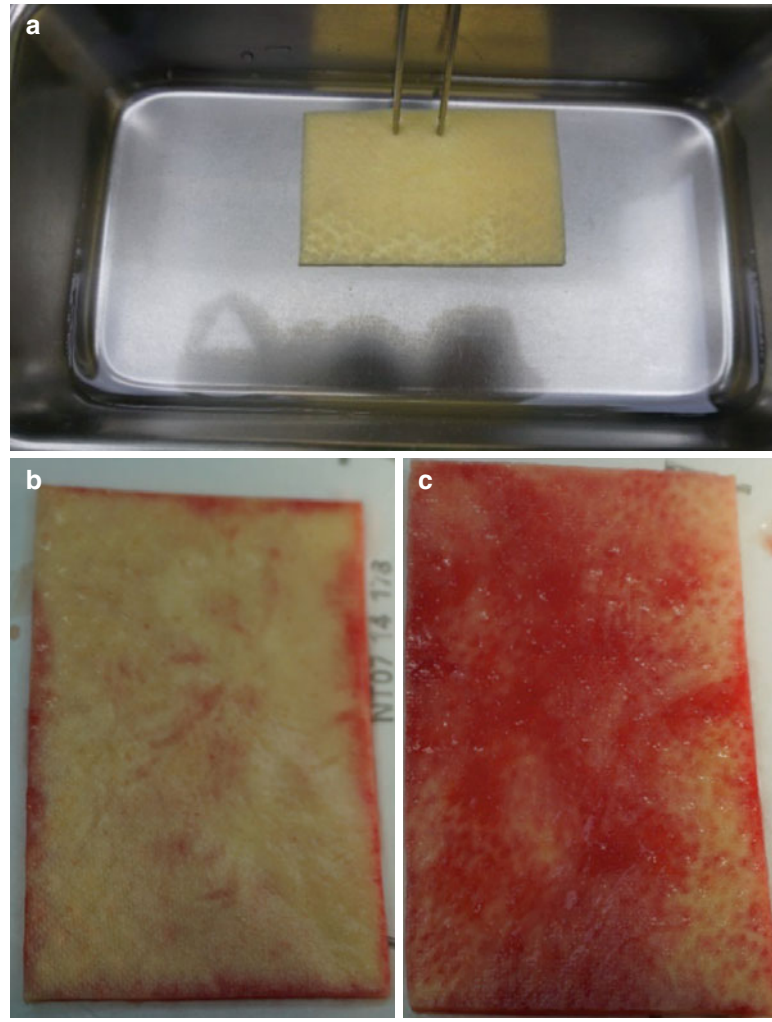

Fig. 11.2 Tissue preparation. (**a**) MegaDerm® is soaked in normal saline with antibiotics. (**b**) The blood washed side. (**c**) The blood-remained side

determined by measuring the distance between the coronary sulcus to the root of the flaccid penis. The allograft is then cut accordingly, and several mesh-like incisions are made on it before grafting (Fig. 11.3).

Operative Techniques

Before operation, the patient must shower and also must shave their pubic hair. In the operating room, the patient receives a second washing with concentrated Betadine solution. Once the skin is prepared with Betadine scrubbing, local anesthesia with mixture 2 % lidocaine and 0.5 % bupivacaine (2:1) is injected into the penile roots and infrapubic area. Afterward, two kinds of approaches can be taken: infrapubic incision and circumcision incision. Infrapubic incision is the preferred method of operation because it causes less complications, such as penile skin necrosis and sutured skin area disruption.

Infrapubic Incision (Fig. 11.4)

Transverse, Z-plasty, or inverted V-Y plasty incision is made on the infrapubic area [13, 14]. Incision is made more deeply, and the infundibular ligament is cut. The incision area is spread open until the dartos fascia is found. The dartos fascia is incised 3 or 4 cm vertically at the proximal dorsal penis, and the dartos fascia is separated from the Buck's fascia on the root of the

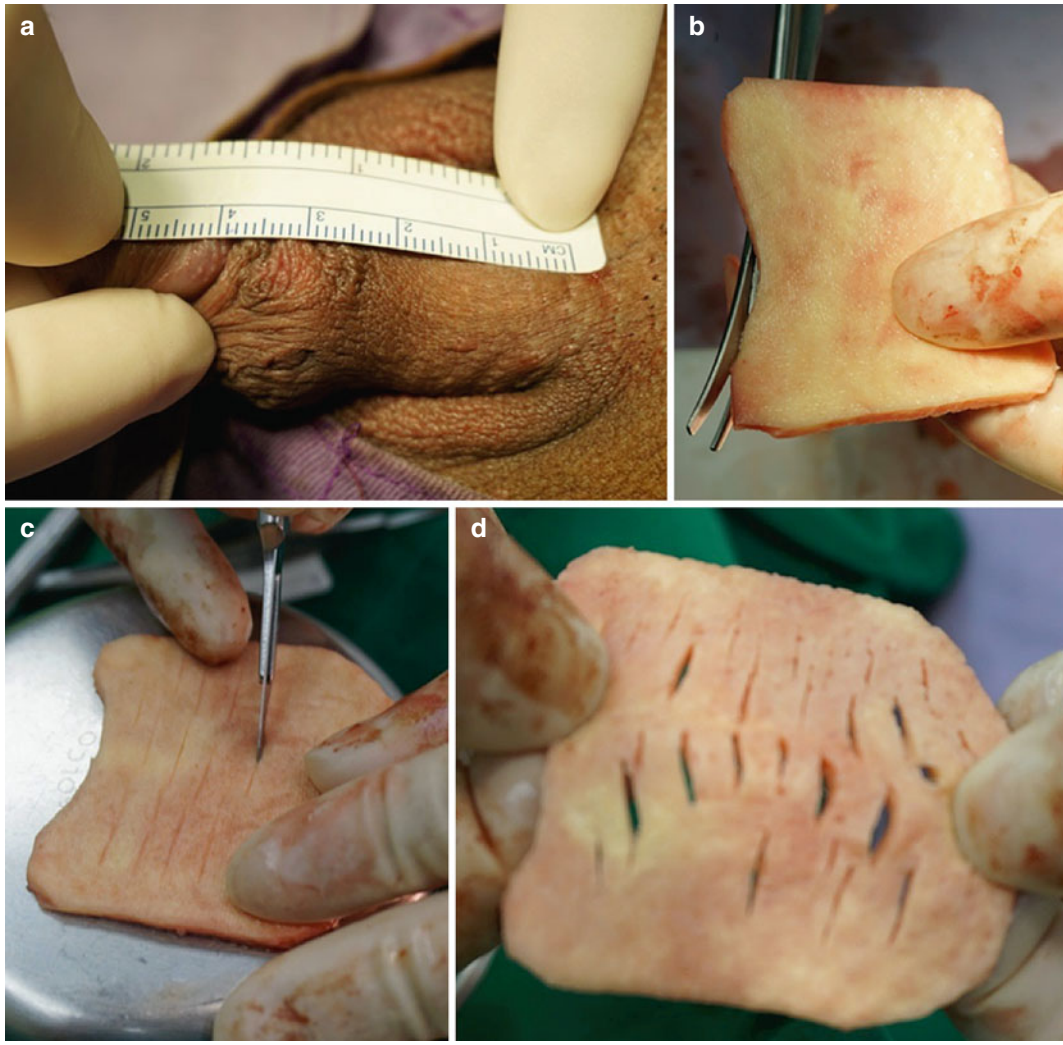

Fig. 11.3 MegaDerm® measurement. (**a**) The length and circumference of penis are measured. (**b–d**) The MegaDerm® is cut and several mesh-like incisions are made

penis. Care is taken to minimize a proximal transverse dartos fascia incision, which can be caused by disruption of the vascular and lymphatic supply of the skin and dartos fascia of the distal penis. Then, the index finger is inserted into the incision area to pull out the penis. Once the penis is pulled out, the dartos fascia on the penis up to the coronary sulcus is meticulously separated from the Buck's fascia. Distal dartos fascia must be released from the underlying Buck's fascia at the junction of the glans, thereby allowing distal graft placement and preventing an unsightly concavity. Gentle transverse distal Metzenbaum scissors dissection is done until the glans is outlined, which makes the distal dissection less traumatic. Care is taken to avoid injury to the distal neurovascular structure which can occur if Buck's fascia is violated.

The prepared allograft is then placed in between the dartos fascia and Buck's fascia with the blood-remained side of the allograft facing the Buck's fascia. The allograft is fixated onto the penis with 4-0 absorbable braided polyglycolic acid coated suture at eight points: three on the coronary sulcus, including one at the center and one each on the corpus spongiosum borders;

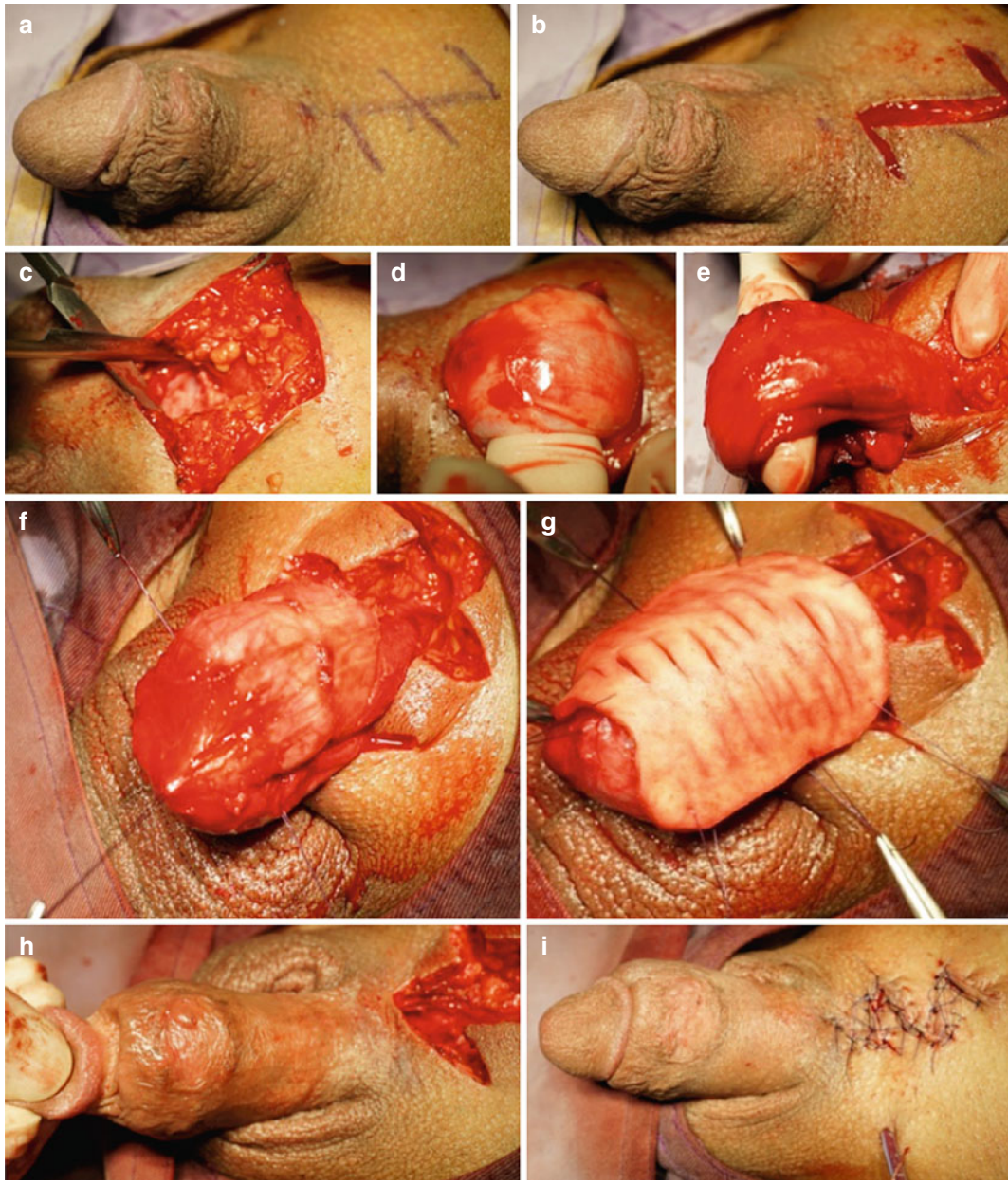

Fig. 11.4 Allografting with infrapubic incision. (**a**, **b**) The double Z-plasty incision is made. (**c**) The incision area is spread open until the dartos fascia is found. (**d**, **e**) The index finger is inserted into the incision area to pull out the penis. (**f**, **g**) The allograft is fixated onto the penis with 4-0 Vicryl at eight points: three on the coronary sulcus, three on the proximal penis, and one on the center of allograft at both corpus spongiosum borders. (**h**) The penis is placed back into its original position. (**i**) The dartos fascia, subcutaneous tissue, and skin are sutured. A small drain is placed by the pump in the in the infrapubic area

three on the proximal penis, including one at the center and one each at the corpus spongiosum borders; and two on the lateral sides of the penis, including one each at the center of the corpus spongiosum borders. Ventrally, care is taken to place the graft distally without injuring the urethra. If a circumferential wrap is not performed, the graft is sutured to the other junction of the

spongiosum and the corpora cavernosa. The graft is then attached proximally to the Buck's fascia, taking care not to entrap dorsal nerves of the penis. The graft must be loose circumferentially and longitudinally to prevent a graft scar contracture from form restricting an erection [15].

Once the fixation is complete, the penis is placed back into its original position. The graft must be further thinned if the skin is too tight because excessive tension can cause venous congestion and skin necrosis. Finally, the dartos fascia and subcutaneous tissue are sutured with 4-0 absorbable braided polyglycolic acid coated suture, and the skin is closed with 4-0 nonabsorbable monofilament nylon suture. A small drain is placed by the pump in the infrapubic area and usually removed in 24–48 h.

Circumcision Incision

For circumcised individuals, incision is made on the entire circumcised portion of the penis. For non-circumcised individuals, incision is made on the point located 1–1.5 cm below the coronary sulcus, and excess skin may be removed if necessary. When operating only for penile girth enhancement, performing partial incision without extending into the ventral part is preferable, as it saves the blood supply flowing to the distal penile skin (Fig. 11.5). The incision is made until the Buck's fascia is reached. Then the dartos fascia is separated from the Buck's fascia to the root of the penis.

The prepared allograft is then placed in between the dartos fascia and Buck's fascia and fixated in the same manner as in the infrapubic incision method. Then the subcutaneous tissue is sutured with 4-0 absorbable braided polyglycolic acid coated suture, and the skin is closed with 4-0 nonabsorbable monofilament nylon suture.

Uncircumcised patients pose a special problem. Although the allografts do not extend into the prepuce, marked swelling can cause phimosis or paraphimosis. If the patient does not agree to circumcision, several temporary sutures through the distal foreskin opening may tighten over the glans to prevent the foreskin from retracting behind the glans. These sutures are also removed in 5 days. The prepuce will remain swollen for up to several months. If the prepuce is relatively tight, a partial dorsal slit is mandatory [15].

Postoperative Management

The penis is wrapped with Mediform and gauze. Then it is slightly compressed using a Coban band, and this state is maintained for 5 days (Fig. 11.6). Immobilization is necessary for graft "take," and therefore, Mediform or Tegaderm dressing followed by Coban or Elastoplast must be applied. Do not make dressing too tight, for it can cause further venous congestion of skin. Removal of the dressing is done on 5th postoperative day because "take" requires at least 4 days of immobilization [15].

A graft survives for the first 24–48 h by absorption of the fluid from the tissue bed in a process called plasmatic imbibition. At 48–72 h, blood vessels proliferate and nondirectional blood flow occurs. By the 4th day, circulation is restored, vessels are remodeled, and collagen is produced. Therefore, survival of the graft is determined in most instances by day 5 [15].

Intravenous antibiotic therapy (an aminoglycoside plus a cephalosporin) is used for the first 2 days and oral antibiotics (a cephalosporin) are administered for an additional 7 days. The nylon is completely stitched out at least 8–12 days postoperation depending on the patients' condition. Sexual intercourse can be resumed in 4 weeks after the operation. Smoking and drinking must be stopped at least 1 week before and 2 weeks after the operation. This is very important for survival of the patient's graft.

Results

Penile lengthening and girth enhancement with allograft or xenograft can be done simultaneously in most of patients. When the patients want penile elongation after penis enlargement

Fig. 11.5 Allografting with partial circumcision incision. (**a**) Preoperative penis with silicone ring under coronary sulcus. (**b**, **c**) Partial incision without extending into the ventral part is made until the Buck's fascia is reached. Then the dartos fascia is separated from the Buck's fascia to the root of the penis. (**d**) Allograft is placed in between the dartos fascia and Buck's fascia. (**e**) The penis is placed back into its original position. (**f**) The dartos fascia, subcutaneous tissue, and skin are sutured

Fig. 11.6 The penis is wrapped with Mediform and gauze, then compressed slightly using a Coban band, and this state is maintained for 5 days

with injection, additional penis elongation with ligament release below the symphysis is recommended.

Although unpublished, the author has performed penile augmentation surgery with allografts (AlloDerm® or MegaDerm®) for 24 patients who have been observed at least for 2 years after surgery. Their average age was 39.8 years. Twenty of 24 surgeries (83 %) were successful. Allografts were absorbed in two patients. With two patients, one developed skin necrosis and the other showed infection. In the non-erect state, the average circumference

Fig. 11.7 Patient who underwent removal of silicone ring and allografting with MegaDerm® had silicone ring under coronary. His circumference increased 2.6 cm in at 2 years. Although his length increased minimally, his penis looked significantly longer. (**a**) Preoperative view of penis. (**b**) Postoperative view after 2 years

proximal to glans is 7.6 cm, and it can be increased to 10.8 cm after 2 years, which corresponds to an average increase of 2.2 cm. The average length of 6.5 cm could be increased to 8. 9 cm in flaccid state after 2 years, which corresponds to an average increase of 2.4 cm (Fig. 11.7).

Complications

The most common complication is penile skin edema which can be improved with a slight compressive dressing, but in the case of a large transudate accumulation, it must be aspirated. The most serious complications are penile skin necrosis, infection, and fibrosis (Fig. 11.8). Infection, most commonly, is due to *Staphylococcus epidermidis*, which harbors in the skin. Preoperative and postoperative antibiotics, extensive preoperative skin preparation with Betadine scrubbing, intraoperative irrigation with antibiotic solution, sterile operative technique, and limited traffic in and out of operating room are measures that should be used to decrease the risk of infection [16]. When penile skin necrosis and infection are found, allograft must be removed as soon as possible.

Other complications include skin erosion, suture line disruption on circumcise incision, and fibrosis and resorption of allograft, which can have a severe effect on penile length and function [9].

Summary

Only minimal data regarding the results and complication rate of penile girth enhancement with AlloDerm® are reported. In my experience, it is acceptable to perform a penile enhancement procedure with MegaDerm® on patients deemed suitable because this results in a successful outcome with minimal complications. However, it is also possible that serious life-changing complications such as penile skin necrosis or fibrosis of allograft may occur in a few cases. Therefore, careful procedure and postoperative care are essential. To achieve satisfactory results, it is necessary to explain for patients to understand the principles of allografting. Knowledge of the principles of surgical technique is necessary to prevent skin necrosis, wound disruption, unsightly genital distortion, and poor scar formation.

Due to insufficient data, it is necessary to further conduct scientific and methodological research regarding the effects of this procedure, including randomized clinical trials. In order to more effectively assess and reinforce these results, it would be preferable to establish standardized methods for evaluating how penile size is perceived both personally and objectively. To supplement allografting, it may be reasonable to examine cross-disciplinary literature to handle issues that can arise from penile girth enhancement, including those that are psychological, sociological, or cultural in nature.

Fig. 11.8 Serious complications. (**a**) Penile skin necrosis. (**b**) Allograft infection. (**c**, **d**) Fibrosis and resorption of graft, which can have a severe effect on penile length and function

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Penile Girth Enhancement with Xenograft

12

Joon Yong Kim

Introduction

Surgical techniques involving a variety of implant materials for penile girth augmentation have been reported in the literature [1–3]. Penile girth augmentation involves various graft procedures or injection of materials such as autologous fat injection, liquid silicone, or hyaluronic acid gel [3, 4].

Owing to a dearth of literature on this topic and low-quality clinical studies on augmentative phalloplasty, penile girth augmentation is considered a highly controversial issue, and many complications have been reported.

The complications arising in penile girth augmentation are asymmetry of the penis, curvature, irregular reabsorption, or intense inflammatory reaction. These complications lead to patient dissatisfaction [4, 5]. So, there is a need for scientific and methodological research to develop and validate methods that lead to successful outcomes.

Using biologic grafts in penile surgery is a new approach to generating a new functional tissue from intrinsic host cells, and several types of biological products are available for this purpose. Biologic grafts are derived from mammalian tissues (human, bovine, and porcine sources—dermis, pericardium, and small intestinal submucosa [SIS]) and subjected to various methods of processing (decellularization, cross-linking, sterilization), resulting in an intact extracellular matrix (ECM).

Nowadays, allograft dermal matrixes derived from human sources have been used to provide the cosmetic benefit of symmetry and durability without the need for more complex harvesting from the patient's own tissues. Alloderm (LifeCell Inc, Branchburg, USA) is an acellular matrix product, processed directly from fresh cadaver skin. It has been used to treat burns since 1992 [6]; it is also used in the correction of soft tissue defect, for supporting deteriorated tissues, in breast reconstruction, or abdominal wall repair, and for tendon repair [7–9].

As an alternative, xenografts derived from the dermis and pericardium sourced from animals are also used, but their use in penile girth augmentation is not well reported. Xenografts are categorized according to the source animal and organ from which they are derived. Many xenogenic skin substitutes are commercially available, and the ideal goal of each product is to achieve minimal or no foreign body reaction, rapid host-cellular infiltration and neovascularization, maintenance of structural integrity, and eventual tissue replacement with host tissue remodeling.

Permacol (Covidien, Mansfield, USA) is a porcine-derived dermal collagen tissue, which is processed to remove cellular elements. It is, then, cross-linked with hexamethylene diisocyanate

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(HMDIC). The aim of this process is to achieve resistant ace to biodegradation by native collagenases and improve the tensile strength and, ultimately, the long-term durability. Several studies have reported on the use of Permacol in ventral hernia and abdominal wall repair after excision of abdominal wall tumor, for treating wound infection, and in the removal of infected mesh [10, 11].

Lyoplant (B. Braun Aesculap, Tuttlingen, Germany) is a collagen implant made from acellular, bovine pericardium. This product is mainly used in duraplasty [12]. It is used for watertight closure of the dura mater at the end of intradural neurosurgical procedures. With regard to penile girth augmentation, Kim et al. reported the results of penile augmentation procedures using xenogenic type I collagen [13–15].

SurgiMend (TEI Biosciences Inc, Boston, USA), a xenogenic acellular derma matrix derived from fetal bovine dermis tissue, was originally used for hernia repair [16].

MegaDerm Ultra (L&C BIO Inc, Seongnamsi, Korea) is derived from porcine dermis that is minimally processed to remove epidermal and dermal cells using patented techniques that do not damage essential biochemical and structural components (Fig. 12.1). The specialized fabrication of porcine dermis helps facilitate quick fibroblast infiltration and penetration of newly formed microvessels, so it can be considered advantageous in improving the quality of wound healing and tissue remodeling [17, 18].

Fig. 12.1 Porcine-derived acellular dermal matrix fabricated with multi-slit and puncture pattern

The non-cross-linked fibrillar collagen in three-dimensional architecture produces a highly microporous matrix that facilitates enhanced host collagen deposition and vascular ingrowth, thus allowing rapid tissue incorporation upon implantation (Fig. 12.2).

Penile Augmentation Surgery

Patient Selection

Patients with the following disorders were considered for surgery: penis shortening due to congenital diseases such as hypogonadism, sexual dysfunction, and/or related mental disorders; penis shortening caused by paraffinoma removal, for example, an injured penis; and social and sexual inferiority complexes due to a physically small penis. However, patients were excluded if they had confirmed mental disorders and personality disorders such as severe obsessive–compulsive disorder, excessive sexual delusions, and sexual vanity; minors were also excluded. The decision to perform a surgery was taken only after careful consideration of the size of the patient's penis in the flaccid and erect states, his level of sexual satisfaction, the level of stress in his social and sexual life, the reason for considering surgical correction, the expectations after surgery, and potential postsurgical complications.

Presurgical Examination and Treatment

Before surgery, the patients' medical history was obtained to check for any history of cardiovascular disease, diabetes, and blood coagulation disorders as well as to determine if they were on any medication. The patients who were on aspirin, nonsteroidal anti-inflammatory drugs, anticoagulants, or steroids were advised to terminate medication use approximately 1 week before the surgery.

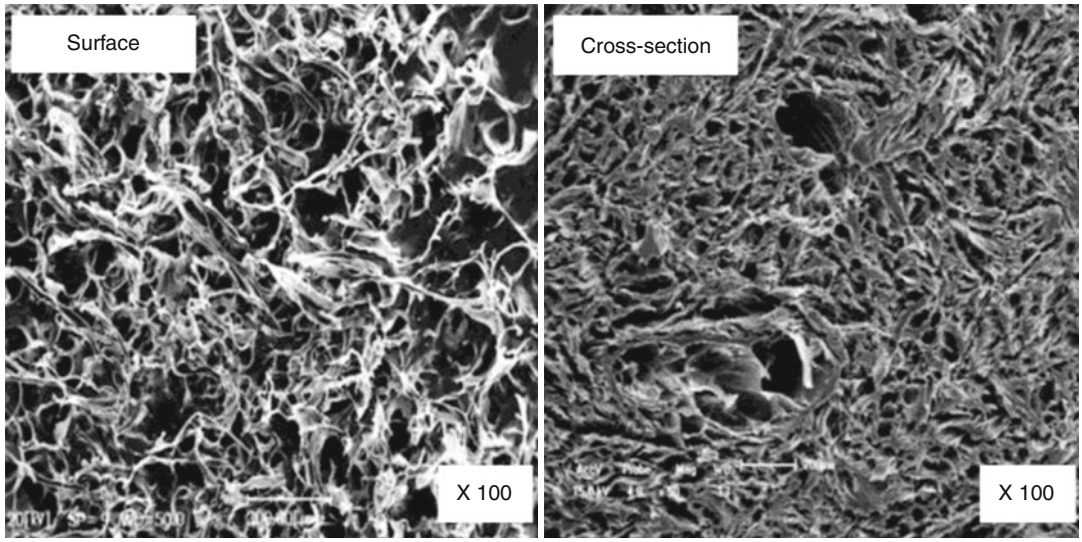

Fig. 12.2 Scanning electron microscopy of porcine-derived acellular dermal matrix in surface (*left panel*) and cross-section (*right*), ×100 magnification

Preparation of the Graft

Prior to the surgery, the graft matrix is cut to the appropriate size and shape that would be suitable for the patient's penis. The length is measured from the girth of the glans to the penopubic junction of the flaccid penis. The width is measured starting at the 4-o'clock position toward the 8-o'clock position at the dorsal side of the penis. It is advisable to avoid inserting the graft in the area around the urethra. Several transverse and vertical slits are then made in them. Finally, additional deeper slits are made on the inner side of the incised grafts [13, 19] (Fig. 12.3 and 12.4).

Surgical Methods

While the main objective of penile augmentation is girth enhancement, this is sometimes accompanied by penile lengthening or glans enhancement surgery. As local anesthesia is sufficient for penile augmentation surgery, the patients were anesthetized with 2 % lidocaine from the proximal part of the penis to the dorsal nerve block (Fig. 12.5a). For those who had circumcision scars, an incision of 3–5 cm was made at the scar on the dorsal side of the penis. In recent times, as younger patients are opting for penile augmentation, they are becoming increasingly concerned about esthetics and the possibility of scar formation after surgery. Therefore, existing circumcision scars are used for penile lengthening/enhancement—such as incision of the fundiform ligament and suspensory ligament along with augmentation surgery of the glans—without the need for an additional pubic incision. An incision was made at the distal penis, penopubic area, or low pubic area that isolated Buck's fascia. Sufficient space to place the graft was secured by parting the prepubic and dorsal areas of the penis from the subcoronal area of the glans at the 4-o'clock position toward the 8-o'clock position, thus minimizing the likelihood of damage to the tissue (Fig. 12.5b, c). The prepared graft was anchored and sutured to Buck's fascia on the distal, proximal, and lateral parts of the penis using absorbable suture material (4-0 PDS) (Fig. 12.5d, f). In cases where an accompanying lengthening surgery was performed, we used a small retractor to separate the relevant parts of the fundiform ligament and suspensory ligament after securing a site in the prepubic portion. Buck's fascia or tunica albuginea was sutured with the subdermal tissue of the penis at two points in the dorsal area or at two points in the ventral area at the junction of the penis and pubic area using synthetic absorbable

Fig. 12.3 Surgical setup

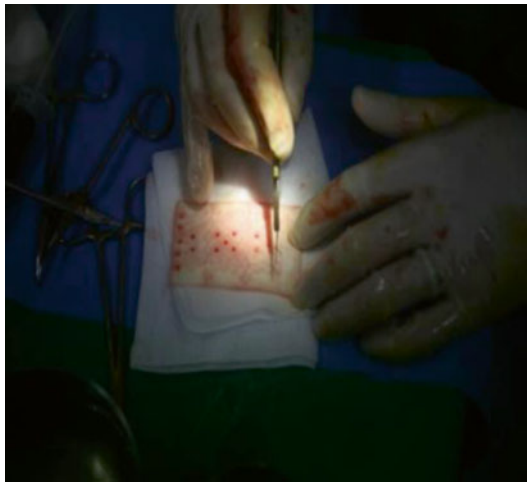

Fig. 12.4 Multi-slit and multi-puncture methods

suture (4-0 Surgifit) on the inner side of the penis or the external skin. During glans augmentation, the skin was peeled off the penis along the upper part of Buck's fascia to the distal part of the glans; the border area of the tunica albuginea of the cavernosum was then separated from the glans at the 10-o'clock position toward the 2-o'clock position to make space for the graft, which was then inserted there. Thereafter, Buck's fascia was covered. On completion of the graft procedure, subcutaneous tissue from the incised area was sutured with the skin in 2–3 layers to avoid graft protrusion, using absorbable sutures.

Postsurgical Treatment and Management

A urethral catheter was not used for draining urine. Oral antibiotics and painkillers were administered for a short period of time. In cases where the patient experienced pain during nocturnal erection, 400–1200 mg of ketoconazole was prescribed. A compression dressing was applied for 2 weeks, and cigarettes and alcohol were prohibited for at least 2 weeks. Patients were advised not to indulge in sexual activities for 4–6 weeks.

Histological Findings After Grafting

There have been a few reports on the histological findings of the graft after penile augmentation surgery. Kim et al. observed the histological findings after surgery with an autograft, allograft, or xenograft [20].

Differences in the histological findings were noted depending on the type of graft used, but the formation of blood vessels and fibroblasts was observed in all cases without any inflammation, provided the surgery had been performed correctly. The histological findings of the graft showed that the xenograft was highly porous, allowing the fibroblasts to move easily through the graft. Although fibroblasts do not synthesize collagen initially, they contribute toward maintaining collagen fiber tissues. Within a few months, the collagen is serially decomposed and combines with new endogenous fibroblasts; in addition, the formation of new blood vessels is also observed.

Postsurgical Complications

Complications that could occur after surgery are penile edema, wound dehiscence, infection, hematoma, penile curvature, and penile deformity. The likelihood of these complications can be reduced by using the correct materials, ensuring minimal damage to the tissues, customizing the size of the graft to the size of the penis, fixing the graft to the

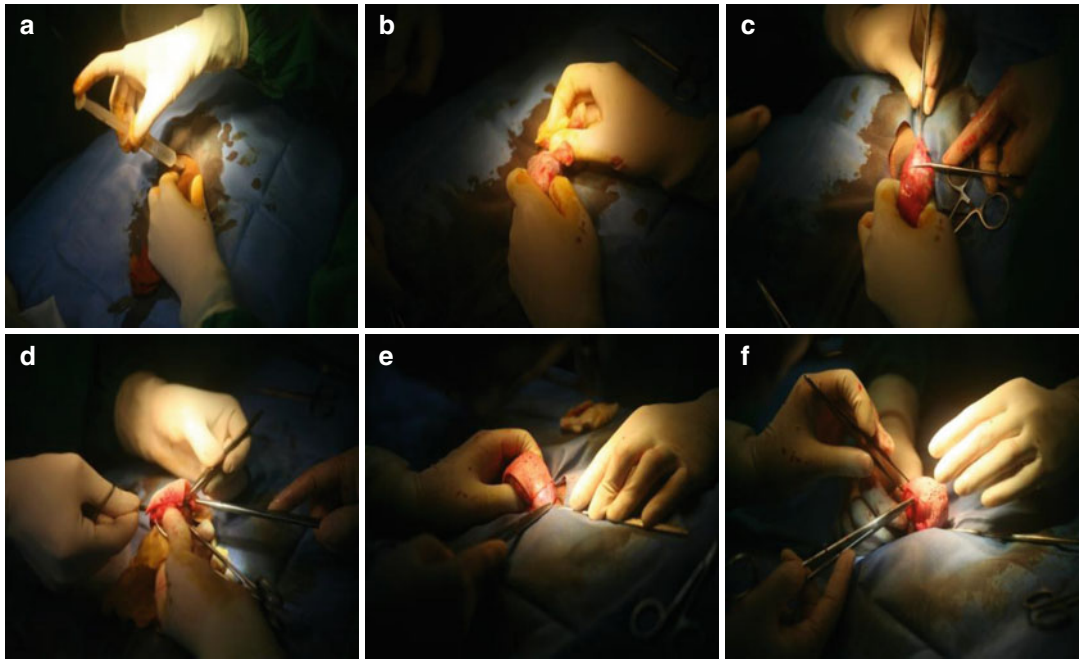

Fig. 12.5 Surgical procedures of xenograft. (**a**) Dorsal nerve block. (**b**) Blunt dissection. (**c**). Sharp dissection. (**d**) Implant fixation: distal penis – near the coronal sulcus. (**e**) Plant fixation: proximal penis. (**f**) Implant fixation: lateral side of the penis

penis without tension, and covering the graft with sufficient subcutaneous tissue to maintain maximum blood circulation. Other complications—such as a change in the color of the scrotal skin, bruising, and edema—normally disappear within 2–3 weeks of surgery [15, 21, 22].

Conclusions

Penile augmentation surgery is safe and does not cause serious complications if the correct methods and materials are used. A successful procedure restores the patients' confidence and enables them to overcome their sense of inferiority caused by their small penises and to enjoy a more satisfactory social and sexual life. Penile augmentation surgery with xenograft has the advantages of being a simple surgical procedure that involves a shorter recovery time and lower likelihood of complications than existing penile augmentation procedures. It can, therefore, be recommended as a favorable surgical method for use in penile augmentation surgery in the future.

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Penile Girth Enhancement with Injectable HA Gel

13

Du Geon Moon and Tae Il Kwak

Introduction

Current criticisms to penile augmentation are that there are no established procedure, poorly defined indications, unacceptably high reported complications, and no reliable long-term satisfactory results [1–3]. So, it raises speculation regarding the true efficacy and morbidity of these procedures. Vardi et al. reviewed the articles published between 1965 and 2008 regarding penile enhancement [3]. Because of disappointing results, they suggested the development of improved criteria for better patient selection, as well as new and better surgical methods of penile enhancement. The main principle of current PGE techniques is the implantation of various bulking agents into the space between Buck's and dartos fascias. But these fascial structures and overlying skin are vulnerable according to the nature of the bulking agents, invasiveness of each technique, and the experience of the practitioner. To save debilitated patients from the adverse effects of previous penile augmentation technique and fulfill the request of the patients, it is necessary to develop a new, safer, and more effective technique rather than criticize penile augmentation or regard it as evil magic.

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The authors already reported the feasibility and 5 year's results of penile glans augmentation using injectable HA (hyaluronic acid) gel [4–6]. Based on the proven safety of HA gel and our experience of PGA, the authors created less-invasive penile girth enhancement (PGE) using injectable HA gel [7].

Materials

Hyaluronic acid has already been used in its native form as an implant for more than 30 years and in millions of individuals without causing adverse reactions [8–11]. In terms of material properties, HA seems to be an ideal filling material for soft tissue augmentation because it is biocompatible, nonantigenic, nonpyrogenic, noninflammatory, nontoxic, easy to use, stable after injection, nonmigratory, and long-lasting but reabsorbable and natural looking [12, 13]. A major advantage of HA gel over nonpermanent fillers, such as fat and collagen, is the increased tissue longevity and low complication rate. The slow degradation of HA gel through cross-linkage enables the several hundred folds longevity of implants compared with the natural polymer, without decreased biocompatibility. The implant has a property of degradation but has a characteristic of isovolemic degradation. Isovolemic degradation always keeps the gel in balance with the water in the tissue, and this increased capacity to bind with water of a less

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concentrated hyaluronan network allows the maintenance of the correction even in the low presence of materials. So, the gross appearance of penis did not show major deformity, but small undulation in surface can occur in some patients because of initial uneven distribution and slow biodegradation.

General Consideration in Patient Selection

For the patient selection, uncircumcised men with redundant prepuce, severe phymosis, and concealed penis with obesity, enhanced penile girth, and thick skin using filler might be problematic. Despite the effort for even distribution into different fascial layers, the fillers might be migrated to the distal prepuce. For severe phymosis or redundant prepuce, circumcision can be recommended. For small penis with obesity or concealed penis, penile elongation should be done before injection of filler. In the contrary, the enhanced girth makes the glans relatively small. Although glans penis augmentation using filler is not widely accepted by the professional society, the glans can be augmented simultaneously or later for esthetic appearance as shown in our previous reports (Fig. 13.1) [5]. Patients should be counseled by a psychiatrist for their sense of inferiority and body image with small penis.

Operative Techniques

Before operation, local scrubbing with Betadine solution is enough and the patient does not need to shave their pubic hair. Under local anesthesia with Emla® (lidocaine 25 mg, prilocaine 25 mg, AstraZeneca Limited, Auckland, New Zealand), Restylane Sub-Q® (Q-Med, Uppsala, Sweden) might be easily injected into the fascial layer of penile body in flaccid state using 21 G cannula (Fig. 13.2) with the "back-and-forth technique." Figure 13.3 shows the anatomic diagrams showing planes of injection. For the ease of injection into the whole length of the penis, cannula can be inserted just above penopubic junction or just below the coronal sulcus at 10–11 o'clock and 1–2 o'clock to avoid dorsal pedicle injury (Fig. 13.4). In long penis or insufficient enhancement of proximal part of the penis, additional injection can be done at just below penopubic junction toward distal penis bilaterally. To avoid urethral injury, ventral side should be enhanced directly. After injection of enough amounts, the penis should be stretched and homogenized with roller for even distribution and to flatten focal lump (Figs. 13.2 and 13.4). The main limitations of penile augmentation using injectable HA gel are not the efficacy but the difficulties associated with the injection technique and the poor learning curve for the beginners. To increase the efficacy of PGE, even distribution of implants at the subcutaneous layer just "deep to" the dartos fascia and patient selection are necessary.

Postoperative Management

Oral antibiotics are prescribed for 1 week. Although the filler was injected into the restricted spaces of multiple fascial layers, the implants might be displaced because the HA gel needs 2–4 weeks for stabilization after injection. Postoperative compressive dressing with elastic bandage should be applied for 1 week. Although focal depression or volume loss by displacement can be easily corrected by reinjection, sexual intercourse should be prohibited until 1 month. Additional nighttime compressive dressing with elastic bandage would be better to prevent focal depression by dependent position of the penis until 1 month. All men have preferential dependency, e.g., right or left side and the resultant skinfold might be developed at one side of penile root in case of enhanced bulky penis.

Results

The authors performed PGE with HA gel in 41 patients (mean age, 42.5 years; range, 27–61 years), who were dissatisfied with their small penis and followed the efficacy and satisfaction until 18 months, and reported the results in 2011.

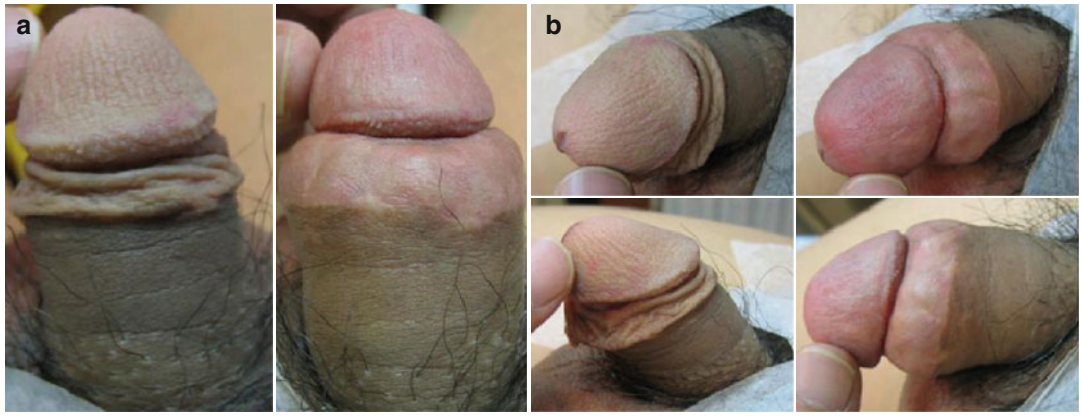

Fig. 13.1 (**a**) Shows dorsal view of the representative figure for penile girth enhancement. (**b**) Shows lateral view with glans penis augmentation using injectable hyaluronic acid (HA) gel at 18 months. The injected HA gel effectively enhanced penile girth, and the implants are well maintained without asymmetry until 18 months. In the augmented penis, the girth and glans are looking good esthetically

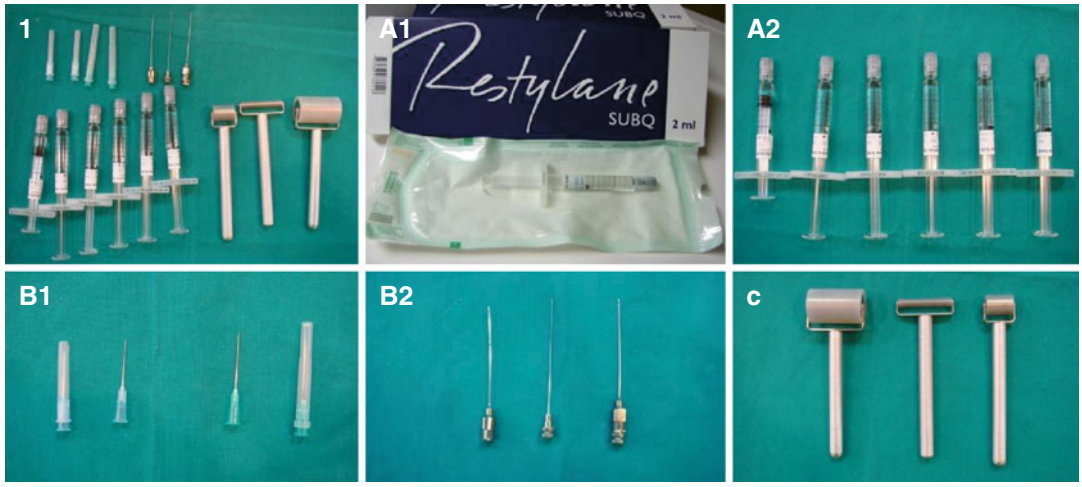

Fig. 13.2 1 is Materials for penile augmentation. (**a**) Restylane Sub-Q. (**b**) Various-sized needle and (19, 21, 23G) cannula for easy injection. (**c**) Roller for homogenization

Mean injected volume of Restylane Sub-Q® was 20.56 cc (18–22).

The major factors influencing long-term efficacy are volume persistence, but there is no established method to measure the residual volume of the filler. The authors estimated the changes of maximal circumference of penile body and patient's subjective visual estimation for volume of residual implants.

Penile girth measurement was performed with the penis on full stretch. Changes of penile girth at midshaft were measured by tapeline at 1 month for early results and were followed at 18 months for long-term results. Every measurement of the circumference was performed by one doctor to exclude interpersonal variation. Compared with basal girth of 7.48 ± 0.35 cm, the maximal circumference of midshaft was significantly increased to 11.41 ± 0.34cm at 1 month ($P<0.0001$) and maintained as 11.26 ± 0.33 cm until 18 months. There was no significant difference between the maximal circumference at 1 month and at 18 months. The net increase in girth was 3.92 ± 0.25 cm (3.4–4.4) at 1 month

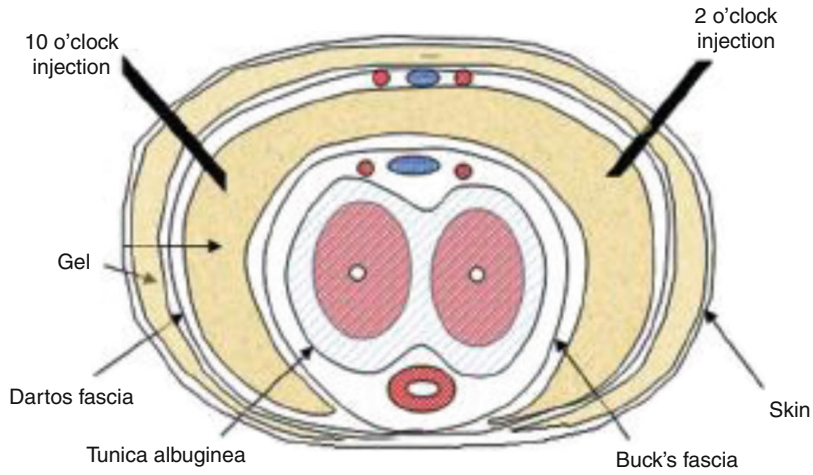

Fig. 13.3 Cross-sectional view of anatomic diagram showing planes of HA gel injection. The hyaluronic acid (HA) gel was injected in the subcutaneous layer, just "deep to" the dartos fascia just below the coronary sulcus and just above the penopubic junction

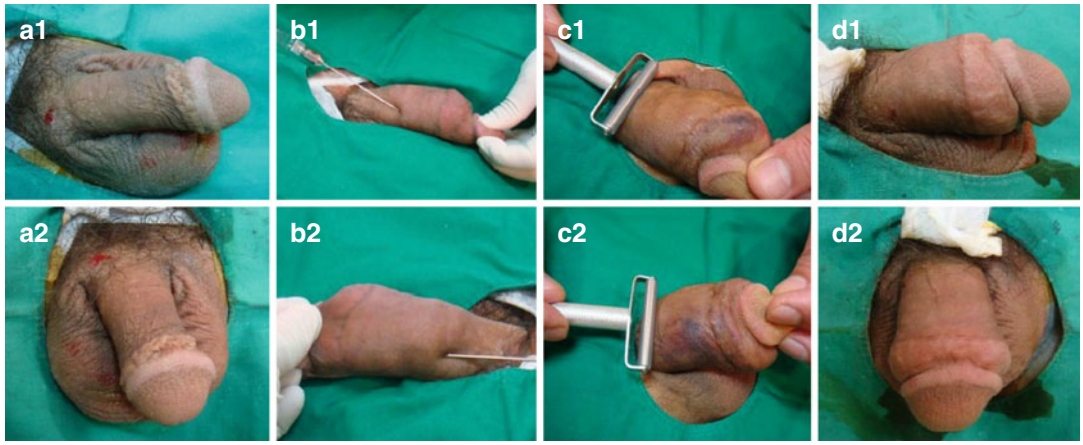

Fig. 13.4 Representative figure of penile girth enhancement using injectable hyaluronic acid gel. (**a**) Preoperative figure of penile girth. (**b**) Filler was injected into the fascial layer of penile body using 21G cannula with the "back-and-forth technique." For the ease of injection into the whole length of the penis, cannula was inserted just above penopubic junction or just below the coronal sulcus at 10–11 o'clock and 1–2 o'clock to avoid dorsal pedicle injury. (**c**) Initial uneven distribution can be manipulated with roller. (**d**) Immediate postoperative figure of penis

and significantly decreased to 3.78 ± 0.26 cm (3.2–4.2) at 18 months.

Patient's subjective visual estimation of penile girth was also requested to assess the residual volume of HA gel at 1 month and at 18 months. The patients estimated using the visual analogue scale from Grade (Gr) 0 to Gr 4 where: Gr 0, no residual volume; Gr 1, less than 25 % of initial volume; Gr 2, less than 50 %; Gr 3, less than 75 %; and Gr 4, more than 75 % or nearly same as initial volume. In patient's visual estimation of residual volume, two patients complained the decrease of the girth as Gr 3 with focal depression, and the rest was Gr 4 at 1 month. In those two patients, refill was done at 1 month (Fig. 13.5) and was followed together. At 18 months, all patients answered as Gr 4 without asymmetry (Fig. 13.1).

Among the limitations and debates of PGE, the long-term satisfaction is very important. Both patient's and partner's satisfaction were assessed

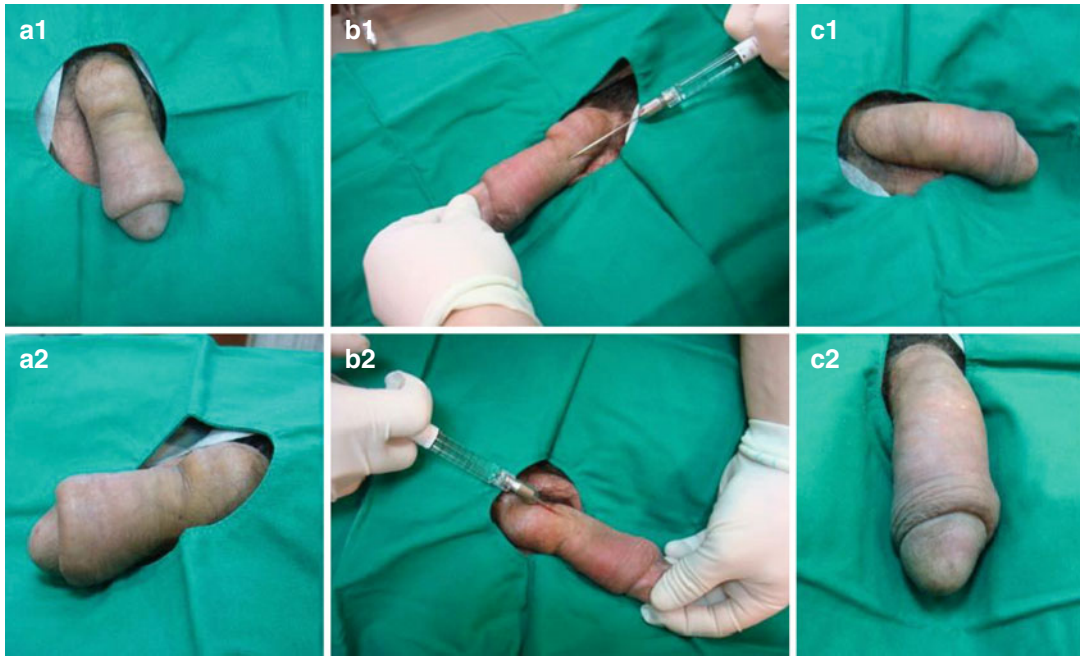

Fig. 13.5 Reinjection for correction of focal depression at 1 month. Focal depression developed from early sexual intercourse can be easily corrected by more superficial refill using 19G cannula. (**a**) Pre-corrective view. (**b**) Intra-corrective view. (**c**) Post-corrective view

using five Grades (Gr 0, very dissatisfied; Gr 1, moderately dissatisfied; Gr 2, about equally satisfied and dissatisfied; Gr 3, moderately satisfied; Gr 4, very satisfied) at 18 months. All couples were satisfied until 18 months in this study. Patient's satisfaction score was 3.71 ± 0.46 at 1 month and 3.34 ± 0.53 at 18 months. In terms of percentage, 29.3 % scored 3 and 70.7 % scored 4 at 1 month and 61 % scored 3 and 36.6 % scored 4 at 18 months. Partner's satisfaction score was 3.65 ± 0.48 at 1 month and 3.38 ± 0.49 at 18 months. The relatively low satisfaction rate of both patients and partners was not from the size because the visual grade was not changed significantly. The low satisfaction rate was partly from lack of total rigidity because the outer enhanced girth is softer than the hard corpus cavernosum in an erected status.

Complications

There were no signs of inflammation and no serious adverse reactions in all cases. For 1.5-year follow-up, there was no serious adverse reaction, like delayed and recurrent chronic inflammatory and granulomatous reactions. There was no deformity with erection compared with the flaccid state. But most patients answered slight decrease of tactile sense of penile body. In two patients, residual volume was decreased to Gr 3 with focal depression at 1 month. On careful interview, they confessed that they had sexual intercourse after 1 week despite our warning. At 18 months, all patients answered as Gr 4. Grossly, all patients might not recognize the volume loss by naked eye. Theoretically, hyaluronidase infiltration is effective to resolve granulomatous reaction or overcorrection, but no patients used hyaluronidase [14].

Summary

Considering the property of the materials, methods, and follow-up results of 18 months, PGE by injection of filler is not the best procedure, but its advantages over other techniques are less invasiveness, tolerable efficacy, and safety with rare

complications from the proven properties of HA gels. PGE with filler can be done easily with a little experience and might be the better option until future development of an ideal technique. Proper patient selection and lack of total rigidity with corpus cavernosum are the limitations of this technique.

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Silicone Implantation

14

Jae Seog Hyun

Introduction

Penis size is a significant concern for most men and the majority are dissatisfied with their penis size and believe it to be the larger the better. However, most men who are dissatisfied with the size of their penis and believe it to be smaller than average, in fact, possess a penis that falls within the normal range.

Nevertheless, they are dissatisfied with the size of their penis because they might have genital complex. Even though men with genital complex have normal size of penis, most of them believe their penis is smaller than average resulting in experience of shame in public bath or sauna and reduced erectility or sexual pleasure during coitus. Such cases are more frequently observed in Asian countries than in the United States or European countries reflecting the fact that Asians have smaller body size than Westerner [1, 2]. Moreover, as men recently became more easily exposed and influenced by adult movies including pornographies via the Internet, they underestimate the size of their penis by comparing the size of their penis with the size of the movie players' penis and begin to wish they would have larger penis like the players after thinking illusion of sexual intercourse that is performed by the movie players with large penis.

In the past, some men with genital complex received penile enhancement therapy using foreign substances such as paraffin, Vaseline, or plastics by non-health professionals. However, such therapies have severe adverse events that can raise public concerns and should be avoided to prevent fatal clinical outcomes. When such foreign substances were infused into the penis, adverse events include dermal necrosis near penis, stiffening of glans, and, in the worst case, loss of male sexual function. Due to recent social awareness on sexuality and development of advanced materials for medical use, numerous studies have reported safe and efficient procedures with decreased adverse effects that meet the needs of male patients. Silicone implantation is one of the representative procedures [3, 4].

Silicone Implantation

Silicone implantation is a surgical treatment that inserts silicone implants such as silicone ring or silicone bar subdermally under the penile skin to increase penile girth. Silicone implantation is a relatively simple procedure to insert silicone implants with fewer complications such as inflammation and toxicity with easy removal of the implants when the patient or his partner complains discomfort of the implants. Besides, compared to other procedures, silicone implantation

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costs less allowing the treatment more applicable to the larger group of patients for their penile enhancement. Silicone implants are presented in various sizes and shapes to accommodate various penile girths. Such a simple procedure can help alleviating genital complex and increasing satisfaction of female partners by stimulating her erotogenic zone. In addition, silicone implantation has therapeutic benefits on premature ejaculation and has advantages that various penile shapes can be formed with penile enhancement by inserting different shapes of silicone implants.

Since silicone implantation is not inserting patient's own body material, it can cause some feeling of irritation by the silicone implants. However, no further treatment is required because the feeling of irritation becomes adjusted as the implant locates properly under the penile skin. Additionally, recent development of soft silicone implants improves postsurgical satisfaction of the patients.

Type of Silicone Implants

Currently, there are no commercially available silicone implants for medical use in penile implantation because no silicone implants are approved by the US Food and Drug Administration (FDA). In some countries, local products of silicone implants are being used in therapies. Since the silicone implants can be shaped with ease, various sizes and shapes of silicone implants can be manufactured. At the moment, four types of silicone implants, ring type (C-type) (Fig. 14.1), bar type (T-type) (Fig. 14.2), quadrangle type (Fig. 14.3), and ball type (Fig. 14.4), are available in the clinic. They are represented in three different sizes, small, medium, and large, to accommodate various penile sizes of the patients.

In order for mental and physical treatment of male patients who need penile silicone implantation can be divided into two groups, patients with micropenis and patients with genital complex. Firstly, micropenis is usually the result of a penile defect during growth or congenital problems that prevent normal development of penis. Anatomically, micropenis is defined as a stretched penile length 2.5 standard deviations less than the mean for age group. Secondly, psychological perceptions of a small penis despite possessing a penis that falls within the normal range can be defined as genital complex. Penile enhancement surgery can be considered when severe genital complex has been found to contribute to sexual life or social life. Therefore, in order to resolve aforementioned mental or physical problems, harmless and nontoxic silicone implants for medical use can be used to increase penile length and girth and to improve self-esteem by preventing significant shortening of penis. Also, premature ejaculation can be alleviated concomitantly by inserting a silicone implant that has longer girth than glans between the epidermis and corpora

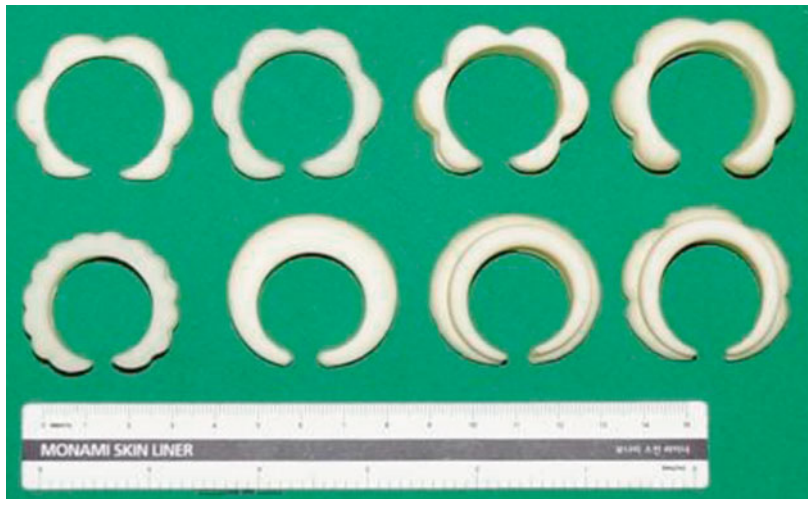

Fig. 14.1 Various C-type (ring-type) silicone implants

Fig. 14.2 Various bar-type (T-type) silicone implants

Fig. 14.3 Various quadrangle-type silicone implants

Fig. 14.4 Small and large sizes of ball-type silicone implants

cavernosa right behind the glans resulting in decreased friction surface of glans.

Surgical Procedure of Silicone Implants

For the surgical procedure of ring-type silicone implants, penis is locally sedated by lidocaine and 1–3 cm (depending on the sizes of silicone implants to be inserted easily) horizontal incision is made from 1 cm below the glans. Superficial (dartos) fascia and deep (Buck's) fascia are separated in both sides enough for the implants (Figs. 14.5 and 14.6). After the placement of silicone implants, proper positioning is confirmed followed by skin closure. Since most of the ring-type silicone implants are C-type instead of complete ring shape, it is unnecessary to peel off the urethra region. This prevents the possibilities that the silicone implants may repress urethra and consequently cause difficulties in urination, disturbance of ejaculation, or urethral damages. In addition, this allows the implants to inflate appropriately when the penile girth changes due to erection.

For the surgical procedure of bar-type silicone implants, it is basically same as the procedure with ring-type silicone implants except for the larger incision of the skin that is required for easy insertion because the bar-type silicone implants are larger than ring-type silicone implants (Fig. 14.6). Therefore, longer incision is made compared to the incision for the ring type, and superficial fascia and deep fascia are peeled off until near proximal end of the penis to insert bar-type silicone implants fully followed by skin closure.

Complication of Silicone Implants

Complication can occur after surgery since the silicone implants are foreign substance like other implants. Postoperative inflammation, the most problematic complication, can be monitored easily with swelling of the implantation site (Fig. 14.7). In case of inflammation, the silicone implant should be removed immediately followed by administration of antibiotics. Reimplantation should be performed at least three months later. The implants may be removed if the patient or sexual partner is not satisfied with the implants due to the feeling of irritation even after some period of postoperative time. With our best knowledge, detailed information regarding the rate and period of postoperative complications has not been reported. Lack of such reports can be explained by the fact that no silicone implant products have been approved by the FDA. Wang et al. reported inflammation in 3.7 % out of 27 rhinoplasty patients with silicone implants [5]. Based on that study, similar rate of inflammation is estimated in silicone implantation surgery of penis [6].

Among various penile enhancement therapies, silicone implantation surgery may have disadvantage of inserting silicone implants instead of

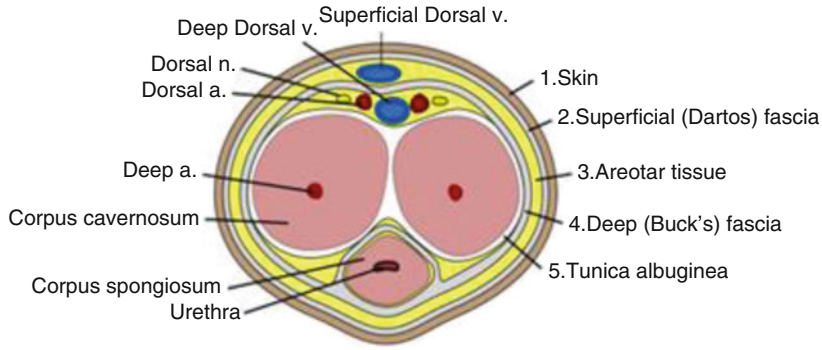

Fig. 14.5 Anatomy of penis. (**a**) Silicone implants are located between superficial (dartos) fascia and deep (Buck's) fascia (**b**)

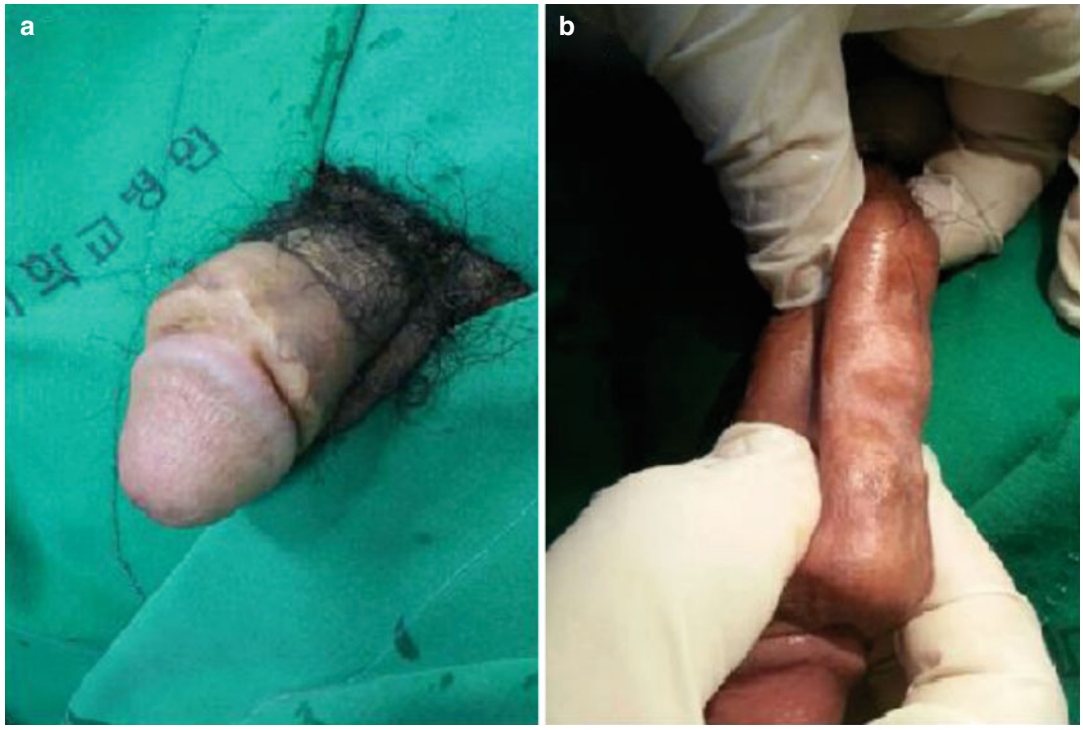

Fig. 14.6 After the insertion of the C (ring)-type (**a**) and T (bar)-type (**b**) silicone implants

Fig. 14.7 Penile prepuce swelling due to infection of silicone implant

patient's own tissues. Nonetheless, advantages that silicone implantation surgery provides include minimal scar and little disruption of normal life after surgery. Moreover, unlike to the autologous transplant of dermis fat procedure that has cell attachment issue, another advantage of silicone implantation surgery is that the result of penile enhancement is not diminished after surgery. Even though several problems exist that there is no official commercialized silicone implant product in the market, the silicone implantation surgery is expected to become a therapy for penile enhancement using various materials or shapes once those problems are overcome.

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Artificial Oil Injection: Complication and Management

15

Jong Kwan Park and Yu Seob Shin

Introduction

In Asian and Eastern European cultures, the bigger penis has been shown as the symbol of power. Injection of foreign materials into the penis in order to make the penis appear bigger has been reported in Asian and Eastern European countries [1–3]. Years after the injection, granulomatous skin and subcutaneous reaction have been called as vaselinoma or paraffinoma.

Because the enzymes in the body are not sufficient enough to metabolize foreign substances, paraffin, Vaseline, cod-liver oil, industrial silicone, and metallic mercury, the inflammation to the foreign body leads to sclerosing lipogranuloma [4–11]. The diagnosis of sclerosing lipogranuloma is based on the physical examination, medical history, and MRI to find invasion of other soft tissues in a specific case of patients. The definitive treatment is a full excision of infected skin and subcutaneous tissue with penile resurfacing. The operations are complicated and time-consuming procedures. Sometimes, a single surgery may not be enough for full recovery, requiring a follow-up operation. However, new methods for reconstruction of penile sclerosing lipogranuloma have been reported recently [12–15]. In this chapter, we are going to introduce the latest reconstructive surgery of penile sclerosing lipogranuloma.

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Cases of Complication of Artificial Oil Injection and Course of Reconstructive Surgery

This section introduces the various cases of complication caused by artificial oil injection including paraffin, Vaseline, cod-liver oil, metallic mercury, and industrial silicone and its management. In addition, the process and results of its reconstructive surgery were documented (Table 15.1).

Case 1 A 37-year-old man presented with penile pain and swelling 2 days before his hospital admission. He performed injections of paraffin into his penis about 7 years ago. On physical examination, penile edema was observed. The reconstructive surgery was done by bilateral scrotal flaps without T-style anastomosis at ventral skin. The T-style anastomosis is the reconstructive surgical method that occurs in the necrosis of ventral penile skin during the surgery

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Table 15.1 Summary of the cases

Case	Age (years)	Injection material	Time since injection	Presentation	Surgical method	Complication of surgery
1	37	Paraffin	7 years	Penile edema	Scrotal flaps without T-style anastomosis	None
2	42	Vaseline	2 years	Tough disfiguring penile edema	Scrotal flaps without T-style anastomosis	Delayed wound healing, traction feeling during erections
3	35	Paraffin	4 years	Inflammatory swelling with necrosis of skin	Scrotal flaps with T-style anastomosis	Wound infection, scar contracture
4	50	Cod-liver oil	Not known	Necrosis of the skin	Y–V plasty	Delayed wound healing at ventral glandular–scrotal skin
5	35	Mineral oil	Not known	Gross deformity of the base of his penis with painful erections	Split-thickness skin graft phalloplasty	None
6	72	Metallic mercury	9 years	Pus-like discharge of silver colored metallic material	Total phallectomy and perineal urethrostomy	None
7	48	Industrial silicone	1 week	Complete necrosis of the skin	Scrotal flaps without T-style anastomosis	None
8	43	Petroleum jelly	3 months	Multiple fistulas, paraffinomas, and bacterial superinfection	Full-thickness skin graft	None

for the penile sclerosing lipogranuloma. The flaps survived completely without ventral skin necrosis or dehiscence between the ventral scrotal and coronal skin (Fig.15.1).

Case 2

A 42-year-old man had undergone an injection of Vaseline into the skin of his penis about 2 years ago. On examination, a tough disfiguring edema was observed. In the operating room, involved skin and subcutaneous tissue were completely removed. The reconstructive surgery was done by bilateral scrotal flaps without the T-style anastomosis at ventral scrotal and coronal skin. Delayed wound healing was seen on dorsal anastomosed site, but the wounds healed with conventional treatment. He had a mildly shortened penis and felt a traction during erections (Fig. 15.2).

Case 3

A 35-year-old man was admitted to the department of urology with inflammatory swelling with necrosis of the penis. He injected paraffin into the skin of his penis about 4 years ago. In the operating room, the involved skin and subcutaneous tissue were completely removed. The reconstructive surgery was done by bilateral scrotal flaps with T-style anastomosis at ventral scrotal and coronal skin. Wound infection developed, but the wounds were healed after 6 weeks of conservative treatment. The mild scar contracture was remained (Fig. 15.3).

Case 4

A 50-year-old man presented in the emergency room for necrosis of penile skin caused by injection of cod-liver oil. The patient underwent emergent initial surgical treatment of abscess drainage and skin debridement. The definitive surgical treatment was carried out when the wound started to heal and showed granulation tissue formation. The V–Y plasty and scrotoplasty to cover the penile skin defect were done. There were no intraoperative or immediate postoperative complications (Fig. 15.4).

Case 5 A 35-year-old man who had an injection of mineral oil under penile skin for augmentation by nonmedical practitioners 3 months ago. Gross deformity of the base of his penis with painful erections and an inability to penetrate during intercourse was found. Penile reconstruction with a split-thickness skin graft phalloplasty was performed. Postoperatively, the patient has a cos-

Fig. 15.1 Preoperative and postoperative findings of case 1. (**a**) Preoperative finding, (**b**) postoperative finding, (**c**) postoperative 12 days, (**d**) removed tissue of penile paraffinoma

metically acceptable penis with normal erections sufficient for intercourse without pain (Fig. 15.5).

Case 6

A 72-year-old man was referred to hospital with a purulent, massive, tender, erythematous, and swollen penis. The penis had an ulcerative lesion on the dorsal surface with a pus-like discharge of silver-colored metallic material. He stated that his penis had been injected metallic mercury 9 years ago. Immediate radiographic examination of his pelvis revealed a large amount of mercury in the subcutaneous tissue of his penis and multiple metallic mercury depositions throughout the pelvic area (Fig. 15.6). Total phallectomy and perineal urethrostomy were performed. The patient was discharged 2 weeks after the operation.

Case 7

A 48-year-old man who had an injection of industrial silicone under penile skin for augmentation by nonmedical practitioners a week ago. Complete necrosis of the dorsal part of penile skin and soft tissue was found. In a penile MRI, big masses of silicone under the penile skin were founded, and a part of silicone was partially exposed. Debridement of necrotic tissue was done. On 23 days after debridement, the reconstructive surgery was done by bilateral scrotal flaps without T-style anastomosis at ventral scrotal and coronal skin. Flaps survived completely without skin necrosis or dehiscence (Figs. 15.7 and 15.8).

Case 8

A 43-year-old man who had an injection of petroleum jelly under penile skin for augmentation by nonmedical practitioners 3 months ago. Multiple fistulas, paraffinomas, and bacterial superinfection were found. Penile reconstruction with a full-thickness skin graft was performed that later led to a functional and aesthetical complete restoration to the original condition (Fig. 15.9).

Fig. 15.2 Preoperative and postoperative findings of case 2. (**a**) Preoperative finding; (**b**) postoperative 3 weeks; (**c**) postoperative 6 weeks, dorsal part; (**d**) postoperative 6 weeks, ventral part; (**e**) traction feeling of scrotal skin

Fig. 15.3 Preoperative and postoperative findings of case 3. (**a**) Preoperative finding; (**b**) postoperative 3 weeks; (**c**) postoperative 6 weeks, dorsal part; (**d**) postoperative 6 weeks, ventral part

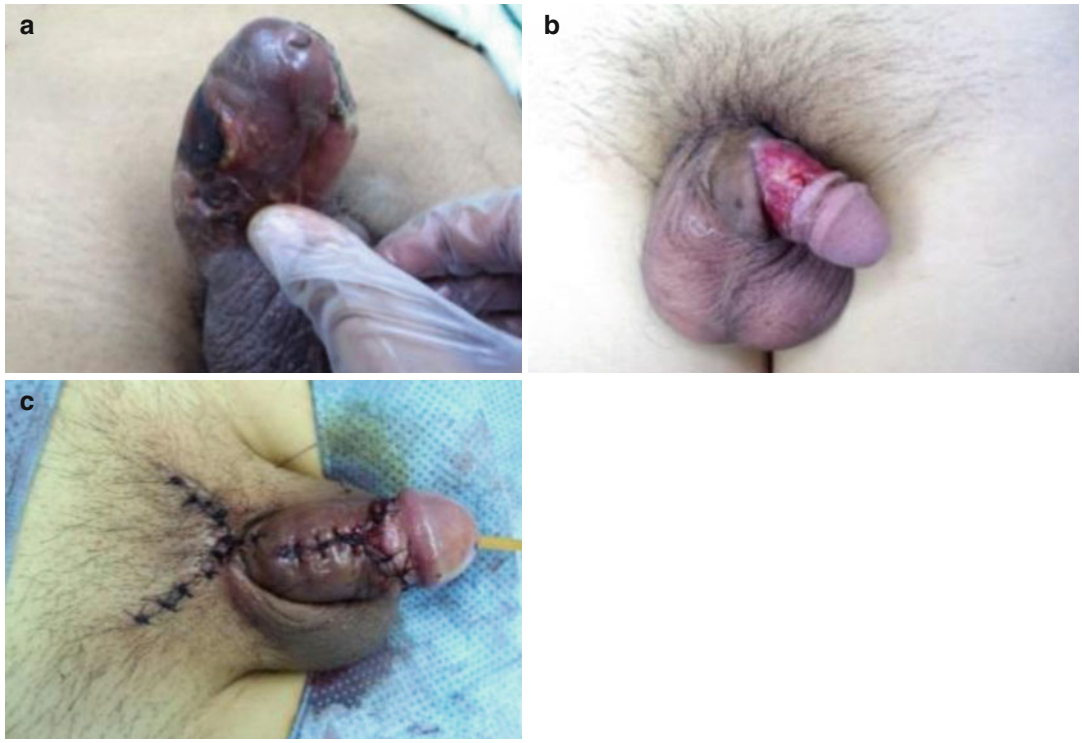


Fig. 15.4 A profile of a case before and after reconstruction showing (**a**) skin necrosis at presentation, (**b**) granulation tissue after excision of the necrotic skin and resolution of infection, (**c**) postoperative picture after penile reconstruction with V–Y plasty and scrotoplasty

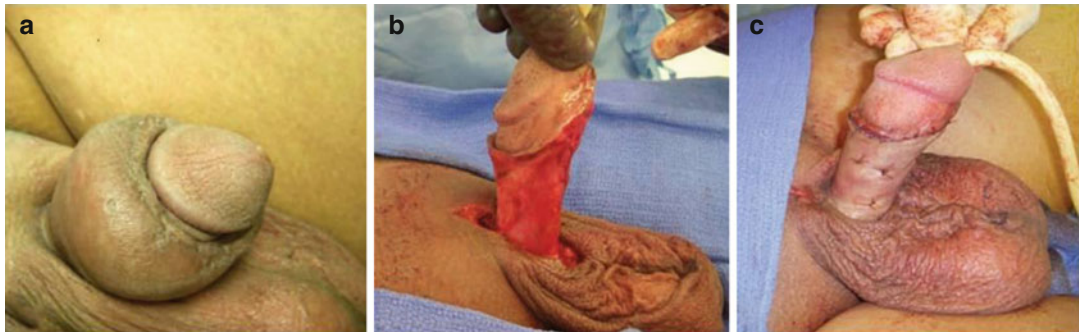


Fig. 15.5 (**a**) Sclerosing lipogranuloma of the penis (**b**) after excision of the suprapubic, penile (**c**) penoscrotal-indurated cutaneous and subcutaneous skin with split-thickness skin graft phalloplasty

Newly Proposed Imaging Study for Help to Planning an Adequate Surgical Strategy for Penile Sclerosing Lipogranuloma: MRI

Penile sclerosing lipogranuloma could be diagnosed by clinical feature of the penis and history of artificial oil or material injection. In addition, newly proposed imaging study, MRI by Cormio et al. [16], will give more information before reconstructive surgery. Using the described MRI sequence, penile sclerosing lipogranuloma displayed low to intermediate intensity on both T1- and T2-weighted sequences, with no contrast enhancement. Taking these findings together, it can be stated that MRI provides an adequate imaging of the histological events occurring after injection of artificial oil or material in the penile subcutaneous tissue. The newly formed fibrotic tissue does not jeopardize the ability of MRI to evaluate the normal penile structures, particularly Buck's fascia and neurovascular bundle. This information is of great clinical relevance in planning the surgical strategy and in counseling for the patient's cosmetic and functional results of surgery (Fig. 15.10).

Current Status of Reconstructive Surgery for Penile Sclerosing Lipogranuloma

New Reconstructive Surgery for Penile Sclerosing Lipogranuloma to Prevent Necrosis of Ventral Penile Skin

Fig. 15.6 Pelvis anteroposterior view showing scattered areas of metallic density in penile shaft and pelvic area

Preoperative Design

Shin et al. [12] introduced a new reconstructive surgery for penile sclerosing lipogranuloma to prevent necrosis of ventral scrotal and coronal skin. The flap design should be marked after the scrotum has been hand stretched adequately by the surgeon. The design of the scrotal flap is determined by the length and circumference of the fully stretched penile shaft with the patient under spinal anesthesia. The length and width of the flap for the dorsal penis are determined by the length and circumference of the denuded penile shaft (Fig. 15.11).

Fig. 15.7 Perioperative findings, silicone, and MRI (**a**) necrosis of penile skin and exposed silicone. (**b**) Removed silicone masses and industrial silicones. (**c**) MRI of multiple silicone masses (*yellow solid arrows*), (**d**) right tunica albuginea invaded by silicone and inflammation (*blue solid arrow*), (**e**) fragile tunica albuginea by inflammation (*white solid arrow*)

Operative Technique

A Foley catheter is inserted into the urethra. Two circumferential penile skin incisions are made to remove the penile tissue invaded by penile sclerosing lipogranuloma: one at the skin just proximal to the corona of the penis and one at the penoscrotal junction. A longitudinal skin incision through the dartos fascia is made on the dorsal surface. The involved skin and subcutaneous tissue are completely removed. Careful dissection is necessary to preserve Buck's fascia and the underlying, dorsal penile neurovascular bundle. Flap elevation for the dorsal penis starts with a midscrotal

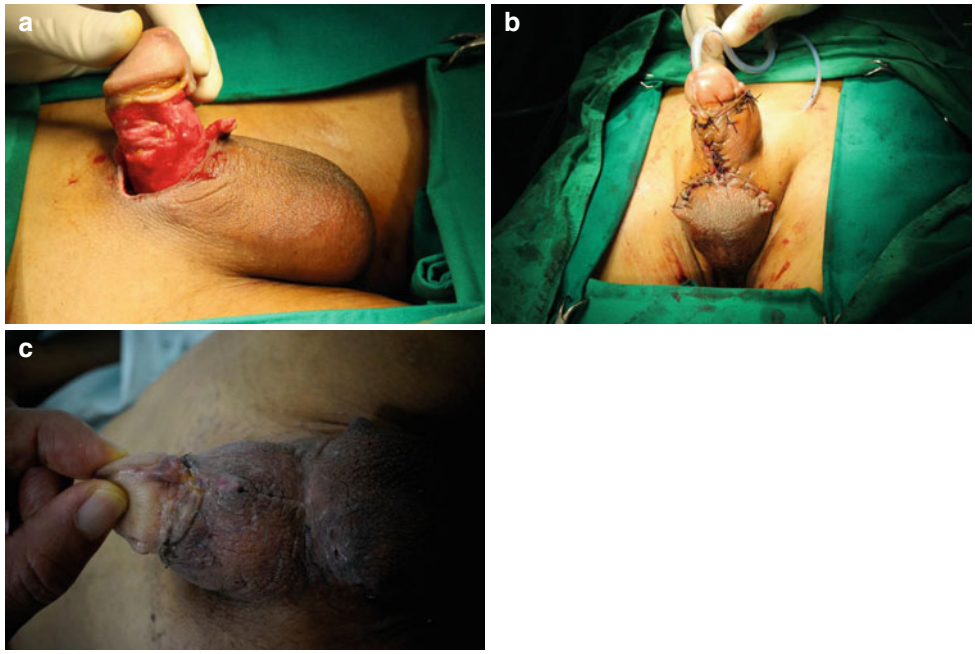


Fig. 15.8 Operative and postoperative findings. (**a**) Clean wound after dressing, (**b**) ventral view of end-to-end anastomosis between glandular penile skin and scrotal flap using inverted V incision, (**c**) ventral view postoperatively 14 days without ventral necrosis

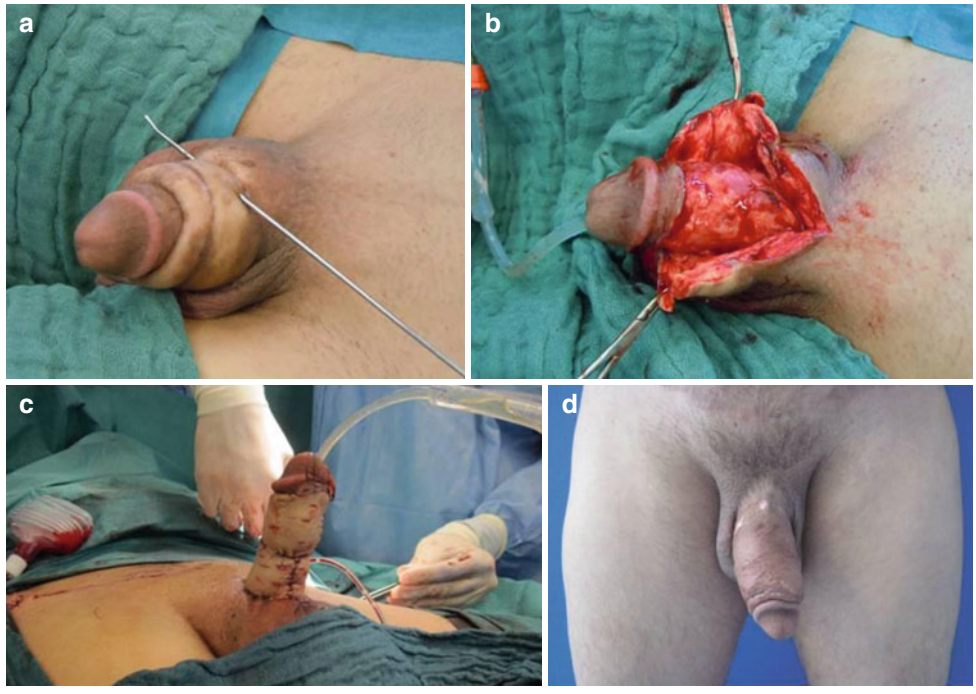


Fig. 15.9 A profile of a case before and after reconstruction showing (**a**) multiple fistulas at presentation, (**b**) granulation tissue after excision of the necrotic skin and resolution of infection, (**c**) postoperative picture after penile reconstruction with a full-thickness skin graft, (**d**) postoperative 6 months. Functional and aesthetical complete restoration to the original condition

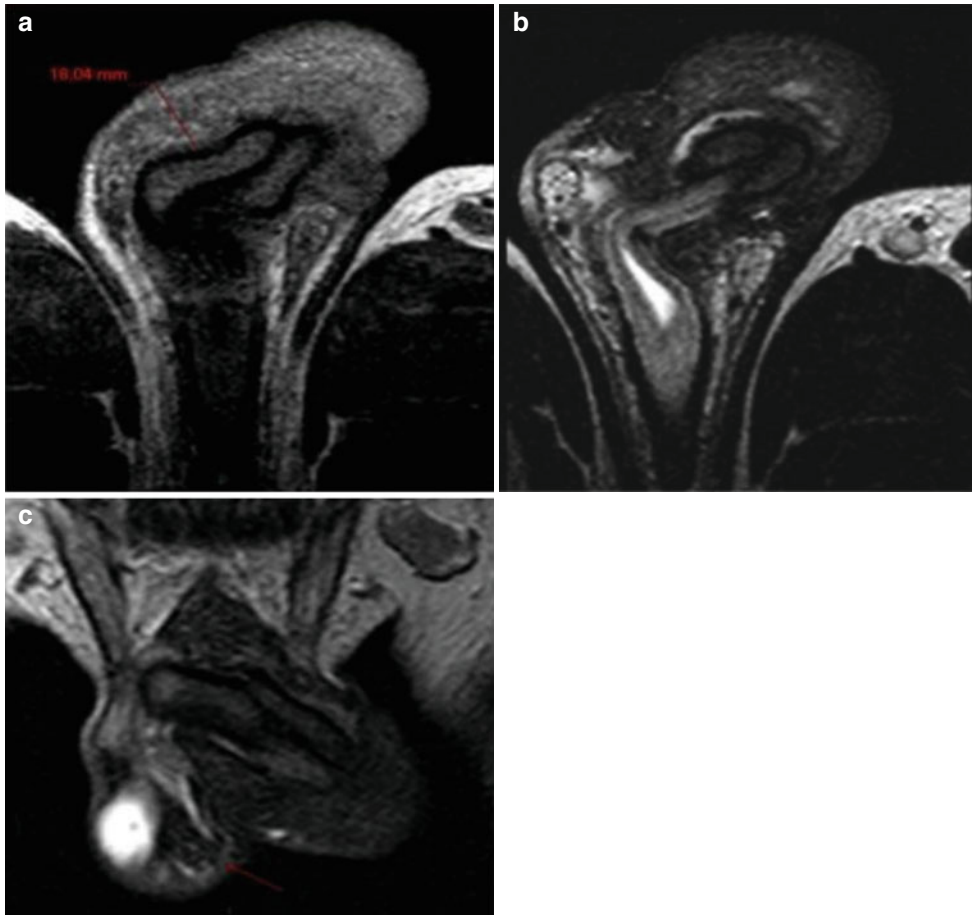


Fig. 15.10 (**a**) Axial T1-weighted TSA MR imaging shows iso-hypointense 18-mm tissue (*red line*) surrounding the corpora cavernosa of the penis. (**b**) Axial T2-weighted TSA MR imaging showing the fibrotic tissue that leads to a severe narrowing of the penile urethra with dilatation of the upstream tract. (**c**) Coronal T2-weighted TSA MR imaging showing fibrotic reaction (*red arrow*) extended in the connective tissue of the scrotal sac

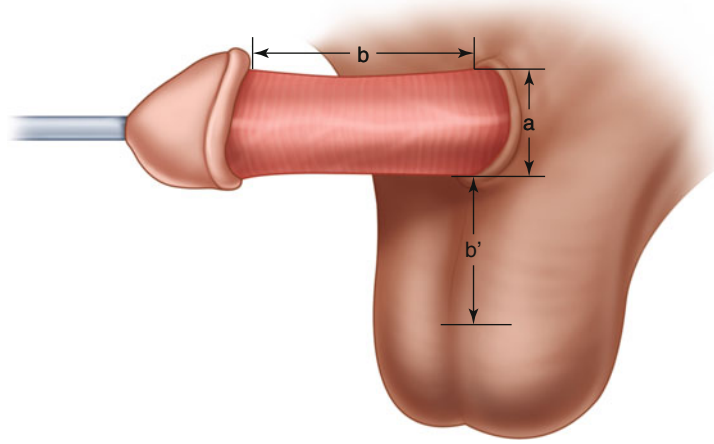


Fig. 15.11 Preoperative design of dorsal penile scrotal flaps. The denuded penile length (*b*) is sum of length of one half of penile circumference (*a*) and scrotum to incise (*b'*)

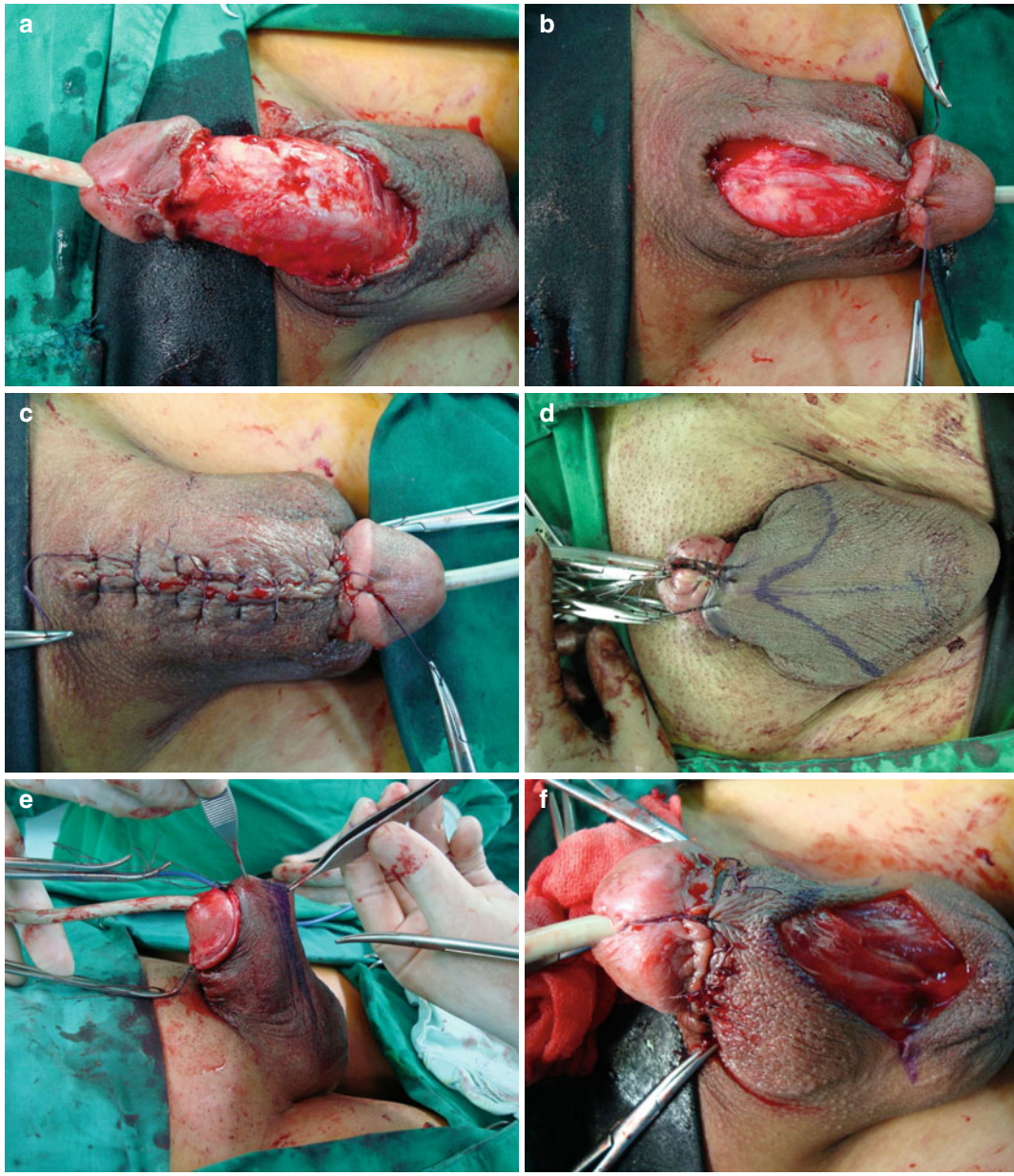
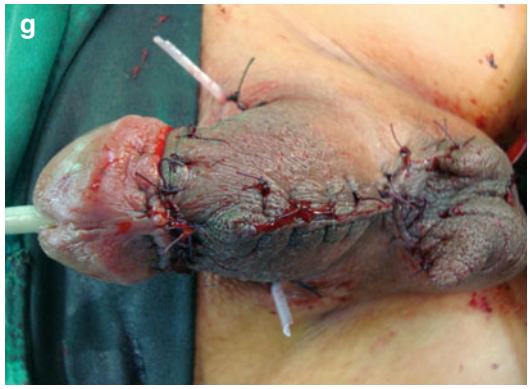


Fig. 15.12 Operative stages. (**a**) Complete removal of infected penile tissue. (**b**) Bilateral scrotal flaps for dorsal penile body sutured at midline coronal skin. (**c**) Completely anatomized scrotal flaps for dorsal penile body using interrupted sutures. (**d**) Ventral aspect of inverted V marking on scrotal skin after end-to-end anastomosis between ventral coronal skin and scrotal flap for ventral penile body. (**e**) Lateral aspect of inverted V marking on scrotal skin. Upper portion of inverted V marking is 1 cm distant from anatomized portion of coronal skin–scrotal flap. (**f**) Scrotal flaps after incision of inverted V marking. Tunica vaginalis peeled off from undersurface of flap. (**g**) Circumferential sutures around corona and ventral vertical sutures placed

Fig. 15.12 (continued)



incision. Both scrotal flaps are sutured to the dorsal midline margin of the corona bilaterally. An end-to-end anastomosis between ventral coronal skin and scrotal flap is performed. An additional inverted V design is made 1 cm below from the midline–ventral portion. The remaining basal scrotal skin is drawn to cover the testes, and sutured layer by layer, after Penrose drains have been placed in the dependent portion (Fig. 15.12).

Results

All 14 flaps survived completely, and the reconstructed penis had immediate postoperative tactile sensibility. In particular, all 14 flaps survived completely without ventral skin necrosis or dehiscence between the ventral scrotal and coronal skin. Delayed wound healing was seen in three patients; the wounds healed with conventional treatment. Major complications, such as flap necrosis and urethral injury, did not occur. Wound infection developed in one patient, but the wounds had healed after 2 weeks of conservative treatment. One patient had mild scar contracture at the penoscrotal junction. All patients were able to feel a gentle touch. Temporary dyspareunia or a feeling of traction during erection was reported by all patients. After a 6-month recovery period, satisfactory sexual activity without the traction feeling was possible for all patients. No patient complained of penile pain during sex or cosmetic problems during follow-up. However, two of the patients who underwent the inverted V-shape anastomosis complained of a mildly shortened penis and a traction feeling during erections.

New Reconstructive Surgery for Penile Sclerosing Lipogranuloma by Bipedicled Scrotal Flap with Y–V Incision

Preoperative Design and Operative Technique

Kim et al. [13] has introduced new reconstructive surgery for penile sclerosing lipogranuloma by bipedicled scrotal flap with Y–V incision. At surgery, a circumferential incision along the border of glans penis was first performed to prevent any damage on uninvolved areas and facilitate extensive excision of sclerosing lipogranuloma for all infected areas. After the removal, the scrotal skin was vertically incised from penoscrotal junction down to the upper part of scrotum in the length of the semicircumference of the penis, and then bilaterally horizontal drawing from this point. After finishing the scrotal flap with the below part of the designed skin and the underneath subcutaneous tissue, the excision of the penis was closed using bilateral coverage and closure. Finally, the inverted V incision and the inverted Y suture on the upper skin with partial resection of suspensory ligament extend the dorsal portion skin toward the penis (Fig. 15.13).

Results

Except the postoperative wound disruption of one patient who had undergone antibiotic treatment and reclosing procedure, all patients had no postoperative complication or serious damage including wound infection, urethral damage, and ischemic necrosis of the penis and were

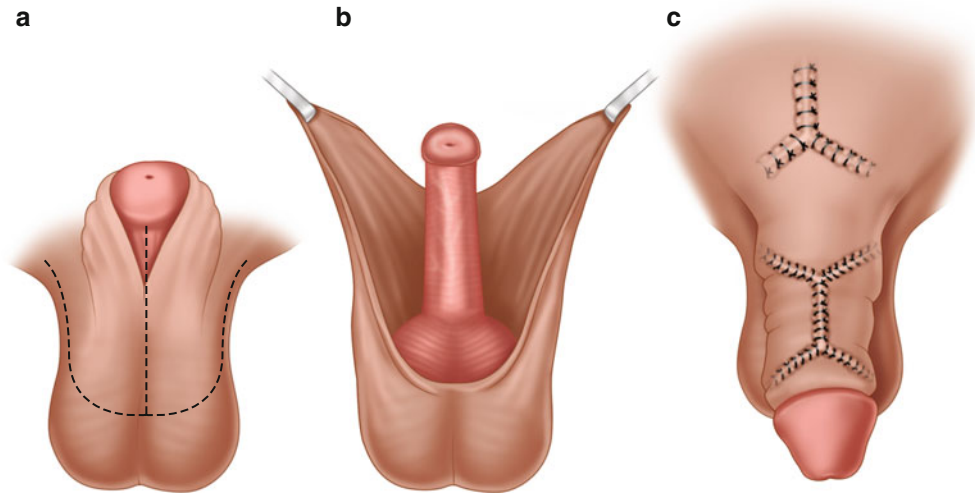


Fig. 15.13 Surgical method. (**a**) Designed skin resection to fit circumference of the penis. (**b**) Perform a bipedicled scrotal flap including subcutaneous tissue and (**c**) penile coverage of dissected penis and Y–V plasty for penile extension

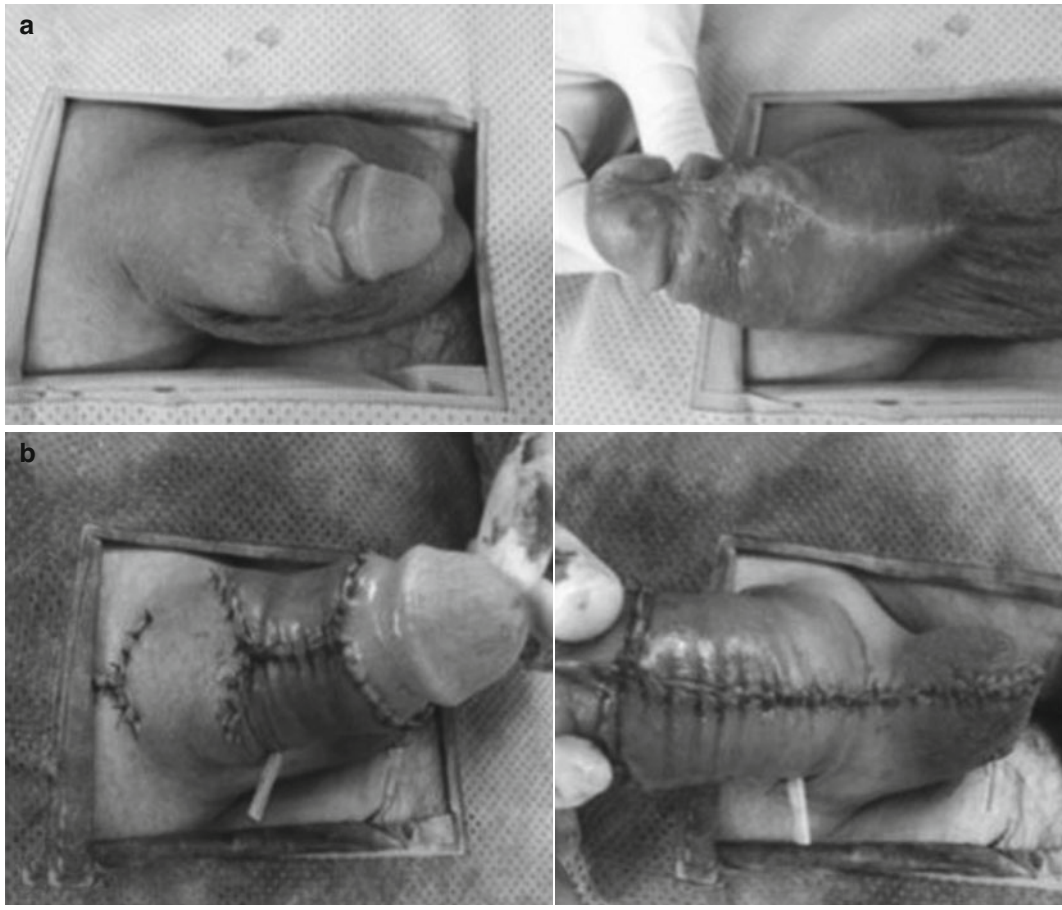


Fig. 15.14 Preoperative and postoperative findings. (**a**) Preoperative finding. (**b**) Postoperative finding and (**c**) postoperative 3 months

Fig. 15.14 (continued)

discharged 3 days after the surgery. There was no shortening in length of the penis or reduction in girth, and the resulting penis had no difference to the normal skin of the penis, with almost no contraction of the scrotum, and all patients were satisfied with the visual postoperative shape of the penis. In addition, all patients were able to recover sexual function and to achieve normal sexual intercourse within 3 months as the longest (Fig. 15.14).

Conclusions

Reconstruction of penile sclerosing lipogranuloma is challenging and requiring much effort. However, the new reconstructive surgery without T-style for penile sclerosing lipogranuloma introduced in the literature recently was more effective and reliable method. They are considered as effective for healing of penile skin and preservation of normal sexual function.

In addition, unrecoverable defected penile tissues would be possible to be reconstructed by using grafts, including synthetic, porcine, or autologous material depending on the development of tissue engineering.

In spite of the successful results of surgery, some patients with penile sclerosing lipogranuloma might prefer to maintain their previous condition of their enlarged penis by injected foreign body after surgery. This questionable preference could result from the psychological and physical benefits associated with penile enlargement. Encountering this kind of patients, surgeons can have a difficult time communicating with them. Therefore, we also have to have the psychiatric consultation for the patient, when the patient would be needing psychiatric support.

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Part III

Penile Lengthening

General Conception of Penile Lengthening

16

Sung Won Lee and Jung Jun Kim

General Concept

A man's identity is often related to the size and appearance of genitalia, and thus, his self-esteem can be impaired if he feels inadequate compared with a perceived ideal. Normal men therefore may desire genital enhancement, because they consider a larger penis to be more aesthetically pleasing or masculine. Such feelings arise from comparison with published photographs, from a sexual partner's ridicule, or from media bombardment describing the sexual benefits of a large penis. Such men may have a lifelong concern about their penis size, frequently relative to the flaccid length, especially in a locker room setting.

Historical Aspect

Penis size has been a source of anxiety for men throughout history, and still today men often feel a need to enlarge their penises in order either to improve their self-esteem or to satisfy and/or impress their partners [1]. A variety of cross-cultural references to penile enhancement exist. The Sadhus Holy Men of India and males of the Cholomec tribe in Peru used weights to increase their penile lengths. Males of the Dayak tribe in Borneo mutilated their penises by forming holes and then sticking decorative items through them for their partner's pleasure.

In the sixteenth century, men of the Topinama tribe of Brazil allowed poisonous snakes to bite their penises in order to enlarge them [2]. The injection of exogenous substances into the genital skin to cause penile enlargement remains a common phenomenon in many cultures. Such practices exemplify the social, cultural, and psychological aspects among men regarding the size of their penises. The tendency of males to seek their identity in the penis with an emphasis on the belief that "bigger is better" and the idea that the penis is central to identity and is symbolically powered are truly significant myths that are firmly entrenched and are likely to persist in modern men [3, 4]. These stigmas of apparently small penises, as well as the increasing influence of the media on sexual issues, have created a demand for penile enhancement. Unfortunately, the need to perform cosmetic surgery in order to enlarge the penis remains highly controversial, and the surgical outcomes are still uncertain [5].

Psychiatric Vulnerability of Surgical Candidate

Aesthetic surgery improves the form of a normal organ for the purpose of enhancing a patient's self-esteem. Many urologists have a bias against

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aesthetic surgery in as much as their training is geared to eliminating disease and treating deformities. However, aesthetic surgery is justified if the potential benefits are positive and the risks are minimal.

The only consensus that exists today regarding the need for such procedures regards surgical correction of a micropenis. The etiology of this relatively rare condition is linked to a disturbance in endocrine function and genetic background of the individual. Reconstructive surgery for this condition is a very challenging procedure because of the anatomical complexity of the penis, which involves both the urinary and genital systems. The use of skin grafts, reconstruction of the urethra, and implantation of an inflatable penile prosthesis are generally required for achieving the desired cosmetic and functional results.

In contrast, the vast majority of men who request penile enhancement surgery usually have a normally sized and normally functioning penis [6]. Characteristically, these patients interpret normal appearances as abnormal, and as a result, they are noticeably distressed and depressed.

Psychological evaluation and treatment are frequently recommended, because surgery does not cure a general lack of self-esteem. Indeed, such surgery is contraindicated in psychologically unstable patients, even though aesthetic surgery can enhance self-esteem and can thus secondarily lead to an improved quality of life, both socially and professionally. Because aesthetic demands and expectations are greater, preoperative and postoperative follow-up is often more time consuming, even with an excellent result. Meticulous surgical technique with dedication to detail is imperative.

These patients are concerned with appearance, and therefore, complications, unrealistic expectations, or inadequate results can cause severe depression. Thus, realistic understanding of the design and limitation as well as a patient's expectations of the surgery must be established to correct misconceptions and prevent dissatisfaction. Some patients may even become violent if dissatisfied and depressed, and thus, honesty, clear communication, and compassions are mandatory for both patient and physician.

Each individual must be evaluated to determine the best methods to achieve his goals. Several procedures are available, depending on the patient's anatomy; both standing and supine examinations are carried out to determine variations that change with gravity. Penoscrotal webbing and extensive suprapubic fat are not usually presenting complaints, but the physician must describe these abnormalities and possible corrective surgery.

Variation in glans size and shape, testicle and scrotal size, and the escutcheon and suprapubic region are more closely examined in the homosexual population. Although physicians should reassure a normal patient, they must not deny his perception. For example, a man with a normal penis may still be a candidate for penile enhancement just as a woman with normal breast size. Postoperatively, a healthier social and professional adjustment occurs owing to increased self-confidence when fear of intimacy and social maladjustment are overcome.

Male genital corrective surgery has always been a highly controversial issue, causing a heated debate in the medical community. The lack of guidelines and of evidence-based studies adds to the controversy. Opinions tend to diverge not only with respect to purely technical issues (i.e., surgical procedures, the absence of consensus for standardization of techniques and outcomes) but also with respect to ethical considerations (i.e., the lack of uniformity relating to indications). This type of surgery should be taken into consideration only for the extremely rare cases of patients presenting with true congenital penile hypoplasia (true micropenis, normally formed but is small in size with a length of 2.5 SD below the normal median) or in the presence of likewise infrequent cases of acquired penile retraction (posttrauma, postinfection, postpriapism, and Peyronie's disease).

In reality, as most requests for this kind of surgery come from patients with normal-sized penises, who nonetheless wish to undergo surgery for psychological distress (penile dysmorphophobia) and aesthetic considerations, this kind of surgery is no longer considered reconstructive but rather aesthetic and calls into play ethics and professional deontology, alongside delicate medical–legal issues.

Penile dysmorphophobia can be functional (i.e., patients are concerned about an unsatisfactory sexual performance because of small penile size) or aesthetic (i.e., the so-called locker room syndrome, which causes loss of self-esteem, social problems, and the refusal to undress in front of other men to avoid comparing penile sizes). The very same psychological reasons causing the patient to request surgery might also cause the patient to be dissatisfied even with the most successful surgical outcome.

For this reason, the cornerstone of reconstructive/aesthetic genital surgery should be a thorough psychological evaluation of the patient, his concerns, self-perception, and expectations. Any suggestion of severe depression or psychosis contraindicates surgery. Interestingly, the 2nd International Consultation of Sexual Dysfunction (2004) [7] demonstrated that thorough and complete information concerning outcomes and complications deterred most patients from actually going through with surgery.

Structured Management and Counseling

Ghanemet al. used a structured protocol for the management and counseling of 250 patients complaining of small penile size [8]. Two hundred and four patients (81.6 %) presented penile dysmorphophobia. Following implementation of a structured management and counseling protocol, 241 patients (96.4 %) agreed that their penile size concerns had been eliminated. Only nine patients (3.6 %) chose to seek further surgical intervention. Two had a buried penis, two had true micropenis, and five had normal penile size. Those five patients with normal-sized penis underwent penile augmentation surgery. The mean postoperative increase in erect penile length was 1.26 cm (range 0.2–2.3 cm). Only one patient with true micropenis and two others with initially normal-sized penis were satisfied with their "new" penile sizes though the rest reported poor satisfaction.

Spyropoulos et al. performed a prospective pilot study introducing a novel questionnaire attempting to identify and to objectively estimate surgical outcomes of candidates for augmentation phalloplasty for penile dysmorphophobia [9]. Forty-five physically normal men completed the augmentation phalloplasty patient selection and satisfaction inventory (APPSSI) questionnaire. It consisted of four questions (scores 0–4). Questions from 1 to 3 were asked preoperatively (suitability assessment) and questions 1, 2, and 4 postoperatively (outcome evaluation). The eligibility threshold for surgery was a preoperative score of six or less. Thirteen out of 45 patients (28.8 %) with an APPSSI score of six or less (mean 3.18) underwent penile lengthening (n¼47), lengthening enlargement (n¼44), or cleioplasty penile lengthening (n¼42). Postoperatively, the score increased by 4.36 (mean 7.54, P <0.001), and the condition improved by 25–50 % in 11 patients, 66.6 % in one and remained unchanged (0 %) in one patient. The mean total penile length gained was 1.6 cm. The average girth gain was 2.3 cm (base) and 2.6 cm (subcoronally). This study was conducted on a small and nonrandomized sample. Validation is warranted for the questionnaire to be considered a valuable clinical tool.

Wylie and Eardley recently released a comprehensive review addressing all topics such as definition, prevalence, concept of normal penile size, etiology, assessment, management, and treatment (including psychological therapy, physical treatments, medications, and surgical treatment) [10]. They recommended that the initial assessment be performed by a team comprising a urologist, a psychosexologist, a psychologist, and, if needed, a psychiatrist. Stretched penile length was typically 12–13 cm, with an erect length of 14–16 cm. Mean girth was 9–10 cm for the flaccid penis and 12–13 cm for the erect penis. A strong correlation exists between stretched penile length and erect length. It is generally accepted that a true micropenis is more than 2.5 SD below the mean length. It was suggested that any penis with a stretched length of less than 7 cm is a true micropenis. More research on race and age influence on penile length is warranted.

Length and Thickness

Erect length may not be a primary concern unless sexual partners have made negative comments. Increased thickness is sought to improve appearance or to increase friction during intercourse,

thereby enhancing pleasure for himself and his partner. Men seeking enlargement place greater importance on length but usually choose both length and girth enhancement. Moreover, a large penis may be a visual erogenous stimulant. It is obvious that size does not substitute for passionate, compatible lovemaking, but some women as well as gay men claim heightened sexual gratification. Although both heterosexual and homosexual men seek surgery, the gay community tends to more concerned with genital aesthetics.

Technical Aspects of Surgery

Advanced techniques to enhance the appearance of the male genitalia have been based primarily on improved reconstructive surgical procedures. During the past several years, enhanced media and patient awareness has led to significant demand for aesthetic surgery of the male genitalia. Considerable improvement in the aesthetic appearance of the genitalia is now possible, although this surgery is challenging, requiring strict attention to detail and meticulous technique.

Lengthening phalloplasty and widening phalloplasty present different technical problems and different solutions. Penile lengthening techniques are beyond a level more limited than those used for penile girth enhancement, with prevalent recourse to penile suspensory ligament division.

Demand for penile lengthening, which is greater than for girth, is achieved by combining release of the penile suspensory ligament with the postoperative use of penile weights. However, interpreting the result of penile lengthening is difficult owing to the lack of a standard measurement technique. Dorsal measurements are taken before and after operation from the pubic symphysis and form the suprapubic skin to the tip of the glans penis on full stretch at a 90-degress angle to the abdomen. Functional and visual penile length can be increased if thick suprapubic fat or subcutaneous tissue is removed by open lipectomy or liposuction. A pharmacologic erection may be performed to measure erect length gain and to document any penile curvature.

The suspensory ligament of the penis is a thick triangular band extending from linea alba and the upper proportion of the symphysis pubis and arcuate ligament to the dorsal midline of the penis. It is derived from the outer investing fascia of the abdomen and divides into a sling at the junction of the fixed and mobile portions of the penis. In addition, thickened bands of Scarpa's fascia, called the fundiform ligaments, firmly attach to the rectus fascia above the pubic symphysis and extend onto the dorsal and lateral penis, possibly restricting penile excursion. Release of the suspensory ligament and restricting bands of Scarpa's fascia can provide slight length increase by inferior displacement of the penis. By separating in part the corpora from the pubis, an optical lengthening effect is obtained; the penis does not actually lengthen but appears to be longer by 1.5–2 cm. Going one step further, this technique could also include the detachment of the cavernous crura from the pubic rami. However, the advantages of obtaining further penile exteriorization are offset by the inevitable downward direction of the penis and penile instability.

True length gain may be achieved by combining ligament release with the use of special penile weights that act as an external tissue expander. Releasing the ligament frees more of the penis to be stretched. Suprapubic skin is not advanced onto the proximal dorsal shaft of the penis unless the patient has a relative deficiency of shaft skin, usually resulting from overly aggressive circumcision.

A redistribution of the penile and scrotal skin is important to obtain a satisfactory aesthetic outcome and avoid reattachment of subcutaneous tissues. Inverted V-Y plasty closure (or Z plasty) of the infrapubic wound is routinely performed. Implantation of pubo–cavernosal silicone buffers and excision of suprapubic fat pad can be added in selected cases. Once the wound has healed, patients must be encouraged to practice postoperative penile stretching, with either the vacuum or the penile stretcher devices. Recently, more invasive surgical procedures have been proposed to obtain a true lengthening of the penis. In 2000, Perovic and Djordjevic [11] described an original

technique involving penile disassembly with interposition of rib cartilage between the glans and the corporal tips. This way, a true penile lengthening by up to 5 cm is achieved, limited only by the length of dorsal neurovascular bundle.

In fact this procedure was reportedly associated with neurovascular bundle damage and ensuing numbness of the glans. Unfortunately, though short-term results demonstrated an increase by 2–3 cm for both the flaccid and erect lengths, no long-term data are available for these patients. Moreover, it is a common knowledge that devascularized rib cartilage tends to resorb over time.

In the mid-1990s, multiple semicircular incisions to the tunica albuginea associated with penile prosthesis implants (malleable, soft, or inflatable) were proposed by Austoni. Incisions are placed asymmetrically to the opposite aspects of the shaft, and defects are covered by venous or small intestinal submucosa (SIS) grafts. Also, this technique provides a true lengthening of corpora cavernosa and is obviously to be reserved for patients suffering from severe erectile dysfunction associated with objectively small penile size, for example, due to Peyronie's disease, previously failed penile surgery or priapism.

Nonsurgical Approaches

Despite demonstration of a normal-sized penis, a certain proportion of patients still request some sort of procedure to enlarge their "underestimated" penis. Surgery, however, is characterized by a high risk of complications and unwanted outcomes, apart from the lack of consensus on indications and surgical techniques used. All those things considered, a nonsurgical approach should be attempted for those patients who persist in requesting treatment.

As for noninvasive physical treatments, various procedures have been attempted – vacuum devices, penile extenders, penoscrotal rings, and botulinum toxin. Among these conservative methods of penile lengthening, penile traction devices are the technique for which the efficacy is supported by some scientific evidence. Taking into account that surgical methods are not supported by a better scientific background nor have they shown better results, penile traction devices could be proposed as a first-line treatment option for patients seeking a penile lengthening procedure.

The same consideration may apply to Peyronie's disease where surgical correction of curvature carries a high risk of patient dissatisfaction because of additional penile shortening. The current evidence suggests that selected cases may benefit from a conservative approach with penile traction devices. In summary, penile extenders are effective minimally invasive methods of penile lengthening, although further studies, preferably comparative, should be performed to gain more scientific evidence.

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Penile Lengthening with Ligament Release and V–Y Advancement Flap

17

Woo Sik Chung and Joon Yong Kim

Introduction

Paintings and records of the ancient Greeks indicate that they believed a small penis was superior [1]. However, as time passed and with various sexual revolutions, many men started to believe that a larger penis is better and that having a large penis in comparison with the penises of rest of the male population is important. Penis size has been a source of anxiety for men throughout history, as evidenced by the use of the terms "phallic identity" and "phallocentrism" in historical accounts. "Phallic identity," as described by Vardi, is the concept of a man seeking his identity in his penis, with a focus on bigger is better. Similarly, "phallocentrism" is the concept that the penis is central to a man's identity [2, 3].

Men often feel a need to enlarge their penises in order either to improve their self-esteem or to satisfy and/or impress their partners [4]. For examples, the Sadhus, i.e., the holy sages of India, and males of the Cholomec tribe in Peru used weights to increase their penile lengths [5]. Many researchers have investigated penile shortening, and penile lengthening surgeries are becoming popular. However, these surgeries have been traditionally reserved for those experiencing shortening of the penis associated with certain medical conditions such as Peyronie's disease, erectile dysfunction, and congenital anomalies and those who have undergone radical prostatectomy because of prostate cancer.

Several studies have focused on penile shortening after radical prostatectomy for prostate cancer [6, 7]. However, penile shortening is not limited to patients who have undergone surgical treatment for radical prostatectomy. Haliloglu et al. found significant shortening of penile length in men undergoing androgen hormone inhibition with radiation therapy for local or locally advanced prostate cancer [8]. In addition, some studies in the literature showed that external beam radiation caused penile fibrosis resulting in penile shortening [9]. The most common etiology of penile shortening is Peyronie's disease [3, 10–12], and erectile dysfunction may be a risk factor for penile shortening [13]. Further, congenital micropenis is caused by a number of medical etiologies. By definition, micropenis is a normally formed penis that is at least 2.5 standard deviations below the mean size; this may be caused by a primary hormonal problem, embryonic testis failure causing insufficient masculinization, bladder exstrophy, and epispadias [14, 15].

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Combinations of Surgeries

The principle involved in penile lengthening surgery is that of making the penis look longer by achieving protrusion of the penis in the flaccid state to the front or in the downward direction. For this purpose, many methods have been combined with plastic surgery techniques involving the skin of the border area between the penis and pubis, such as suprapubic lipectomy and cutting of the fascia or ligament. Occasionally, a penis may appear small because it is partially covered by abundant pubic fat or by a protruding abdomen. In these cases, either abdominal/pubic liposuction or a suprapubic lipectomy is probably the most practical and safest approach to achieving some visual extension of the penis [5, 16, 17].

The mainstay of penile lengthening surgeries is a combination of the release of the suspensory ligament of the penis with inverted V–Y penopubic skin advancement [18] (Fig. 17.1), and many surgeons recommend cutting the suspensory and fundiform ligament in combination with the use of penile weights.

Most lengthening surgeries only affect the non-erect (flaccid) length of the penis, and any postoperative erection will be of the same size as that before surgery but its angle may be slightly lower than that prior to surgery. Roos and Lissoos analyzed the outcomes of 260 cases of penile ligament dissection and skin flap. They found that the average increase in length was 4 cm. No patient reported a decreased angle of erection or changes in erectile function. The majority of the patients were satisfied, and the complication rate was minimal [19].

Klein analyzed the results of penile enhancement surgery performed on 58 young men (mean age: 39.3 years) by 12 surgeons from different clinics. The surgery involved either dissection of the suspensory ligament only (17.2 %) or dissection combined with girth enhancement using fat injection (60.3 %) or dermal (10.3 %) or pedical fat grafts (6.9 %). The resultant change in flaccid penile length was 2.6–9.1 cm, and there were no significant changes in the erect length [20].

Shirong et al. performed 35 penile elongation surgeries in patients who had congenital microphallus. They defined microphallus as an erect length of less than 8 cm in men with traumatic injuries. They performed 52 procedures over a 7-year period in men aged 23–52 years. The procedure consisted of cutting the suspensory ligaments, beginning with the superficial ligaments, and if more length was needed, the deep suspensory ligaments were partially cut. A scrotal flap was used to cover the exposed corpora, and in some cases, a V–Y suture was made on the ventral side to avoid traction and for better cosmetics. Only 20 patients were followed up postoperatively, and an increase in length from 3.5 to 6.5 cm was seen [21].

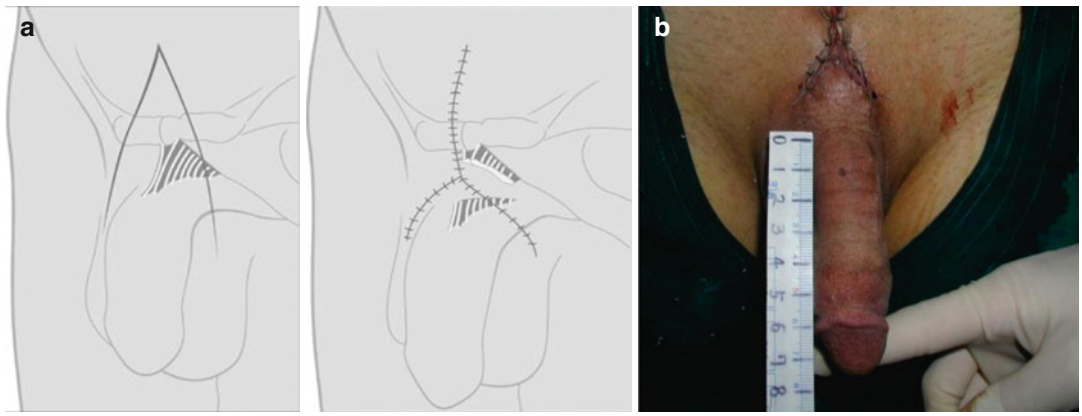

Fig. 17.1 (**a**). Combination of release of the suspensory ligament of the penis and inverted V–Y penopubic skin advancement, (**b**). V–Y plasty

Suspensory System of the Penis

The suspensory system of the penis gained clinical importance in reparative surgery and traumatology owing to its role in erection. The suspensory apparatus consists of separate ligamentous structures: the fundiform ligament that is lateral, superficial, and not adherent to the tunica albuginea of the corpora cavernosa and the suspensory ligament that stretches between the pubis and the tunica albuginea of the corpora cavernosa, consisting of two lateral, circumferential, and one median bundle that circumscribes the dorsal vein of the penis [22] (Figs. 17.2 and 17.3). In other words, the suspensory ligament of the penis comprises two components: the suspensory ligament proper and the arcuate subpubic ligament that attaches the tunica albuginea to the midline of the pubic symphysis [23]. The suspensory ligament of the penis plays a crucial role in supporting and maintaining the penile position at the specific angle that is required for vaginal penetration and sexual intercourse. Detachment of this ligament from the symphysis pubis allows forward movement of the corpora, thereby enabling the penis to extend during an erection [19]. The more superficial fundiform ligament is encountered before the suspensory ligament. This ligament is a continuation of the membranous Scarpa's fascia of the anterior abdominal wall. The fundiform ligament of the penis that supports the penis in a sling-like fashion extends from the linea alba to the penis and surrounds it laterally, ending in the scrotal septum.

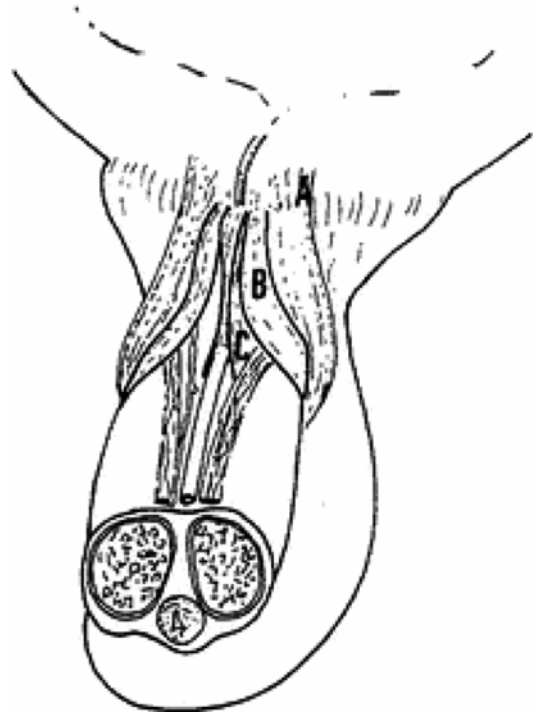

Fig. 17.3 Suspensory apparatus (anterior view). *A*. Fundiform ligament; *B*. lateral bundle of suspensory ligament; *C*. median bundle of suspensory ligament (Reproduced from Hoznek et al. [22] by kind permission of the authors and of Springer)

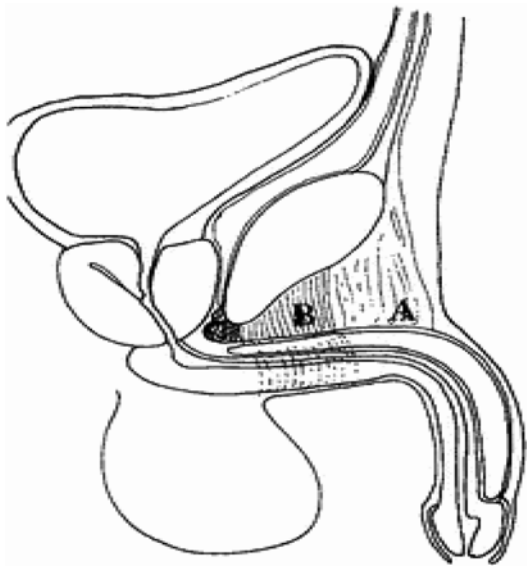

Fig. 17.2 Suspensory apparatus (sagittal section). *A*. Fundiform ligament; *B*. suspensory ligament; *C*. arcuate subpubic ligament (Reproduced from Hoznek et al. [22] by kind permission of the authors and of Springer)

Separation of the Suspensory Ligament and Fundiform Ligament

Surgery is performed under local anesthesia with or without intravenous sedation. We believe local anesthesia is sufficient for penile lengthening surgery. With 2 % lidocaine, anesthesia was given from the proximal part of the penis to the dorsal nerve block along with local anesthesia in the subcutaneous tissues of the penis, as necessary.

Urethral catheter or drainage was not used. Oral antibiotics and painkillers were administered for a short period of time. In the event that the patient felt pain with a morning erection, 400–1200 mg of ketoconazole was administered with 2000 mg of vitamin C as an oral supplement. Compression dressing was applied for 2 weeks and cigarettes and alcohol were prohibited for at least 2 weeks. The patient was advised not to have sex for 4–6 weeks.

Two kinds of incisions are made for penile lengthening surgery: (1) an incision on the low pubic area or proximal penis and (2) an incision on the subcoronal or distal penis (Figs. 17.4 and 17.5). Recently, younger patients have been opting for penile lengthening surgery; owing to their interest in the aesthetic aspect and concerns about scar problems after surgery, it might be beneficial if any existing circumcision scars are used when performing length enhancement. However, a low pubic incision is preferred when skin advancement is necessary. Diverse skin incisions (V-, M-, and Z-incision) are used to advance the skin onto the shaft.

The superficial tissue and Scarpa's fascia were dissected from the corporal body with a sharp and blunt dissection. We used blunt finger dissection to skeletonize a part of the fundiform ligament and suspensory ligament after securing the maximal site of the prepubic area. The fundiform ligament and superficial layer of the suspensory ligament were incised in the midline. However, the deep suspensory ligaments were partially cut if more length was needed. By subtotal cutting of the fundiform ligament below the symphysis, the penis can be elongated. Paniflov described his technique for penile elongation, an incomplete cutting of the fundiform ligament of the penis; this allows for the elongation of the extracorporeal part of the penis. Then, a "V–Y plasty" was used to elongate the penile skin at the base. The average penile length preoperatively was 8.75 cm (6.5–10 cm), and 12 months postoperatively, the length increased to a mean value of 11.14 cm [24].

Dividing the suspensory ligament is a straightforward procedure and can be accomplished through various incisions. The bony root of the ligament is located 4–5 cm below the skin. By performing the dissection just below the pubic bone, the surrounding periosteum, which is a relatively broad and dense fibrous tissue, can be

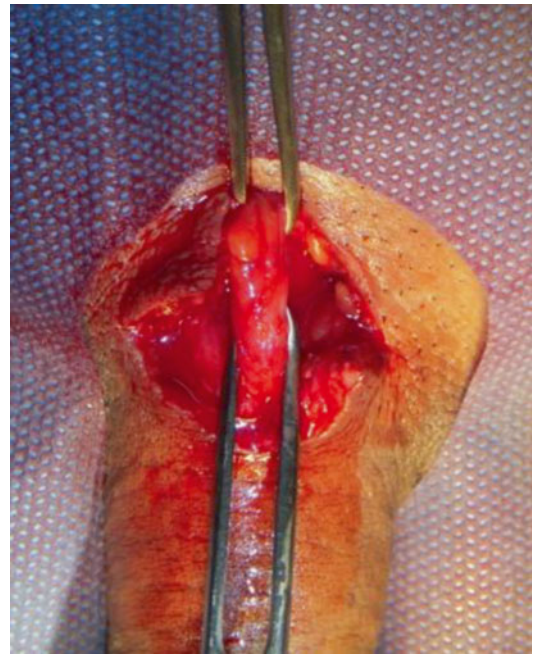

Fig. 17.4 Incisional approach: penopubic incision

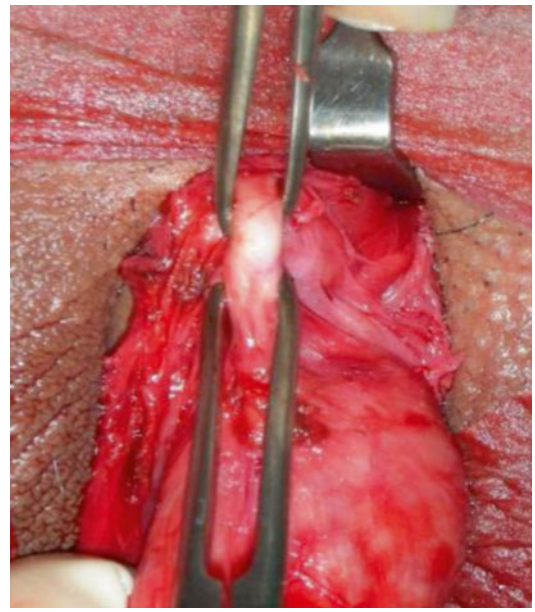

Fig. 17.5 Incisional approach: distal penile incision

released. The deep layer of the suspensory ligament was resected in the same way, resulting in an empty space between the base of the penis and the pubic symphysis. This dead space should be filled because the ligament can reattach and possibly reduce length gain or result in penile shortening. On the other hand, Buck's fascia or the tunica albuginea can be sutured with the subdermal tissue of the penis at two points on the dorsal area or two points on the ventral area at the border area of the penis and pubic area with 4-0 Vicryl (Figs. 17.6, 17.7, 17.8, 17.9, 17.10 and 17.11).

Fig. 17.6 Preoperational stage

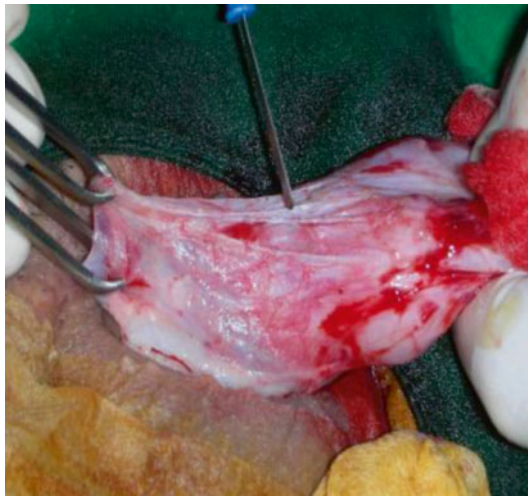

Fig. 17.7 Tissue dissection

Prevention of Ligamentous Reattachment

Reattachment of the suspensory ligaments and penile shortening need to be avoided. After incising the ligament, the surrounding soft tissues and fat tissues, polytetrafluoroethylene, Gore-Tex, and other artificial materials can be used to fill the gap between the penile base and the pubis. Alter suggested the placement of fat tissue

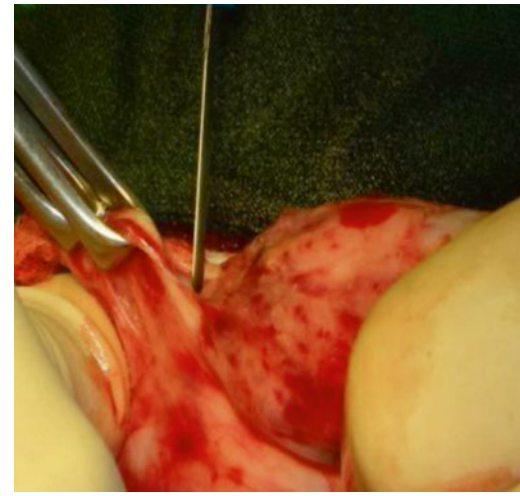

Fig. 17.8 Cutting of the fundiform ligament and suspensory ligament

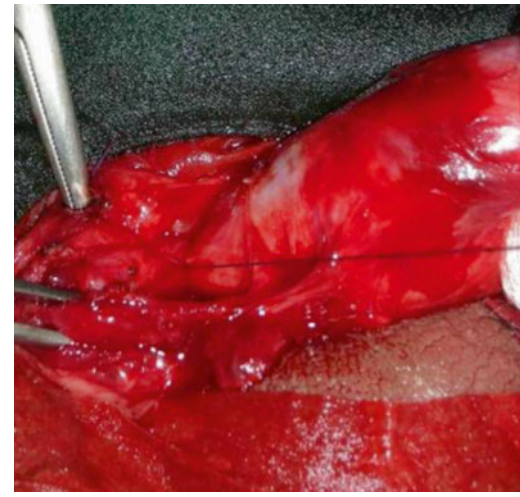

Fig. 17.9 Subdermal(or subcutaneous) tissue is sutured to Buck's fascia(or tunica albuginea) of the dorsal surface of the penis

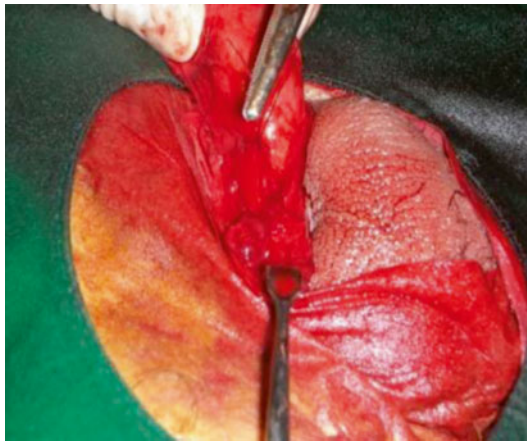

Fig. 17.10 Subdermal (or subcutaneous) tissue is sutured to Buck's fascia (or tunica albuginea) of the ventral surface of the penis. Cutting of the fundiform ligament and suspensory ligament

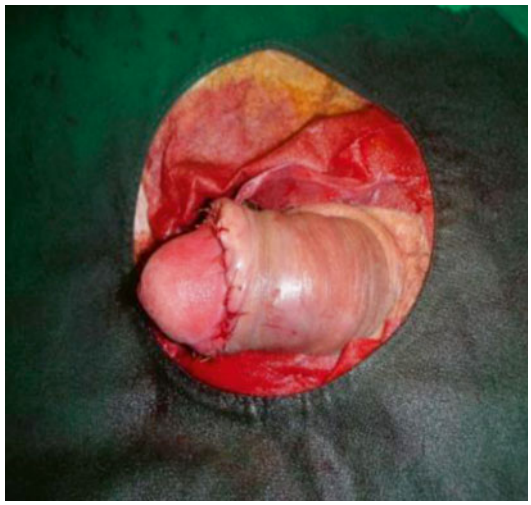

Fig. 17.11 Postoperational stage

between the suspensory ligament and bone to prevent ligament adherence to the pubic bone, which can result in penile shortening [25]. Further, in order to prevent postoperative shortening, Shaeer et al. recommend placing a pubic fat flap between the penis and the pubic bone after the suspensory ligament is released [26]. In addition, Li et al. suggest suturing a small testicular prosthesis to the base of the pubis [23]. Often, a JES extender or penis stretcher with a pendulum is used as standard protocol after transection of the fundiform and suspensory ligament. Penile weights are hung from the corporal ridge, once the patient has recovered from the initial procedure. The weights prevent reattachment of the suspensory ligament and should be worn intermittently throughout the day. Apparently, this process can prevent iatrogenic shortening of the penis and may even add length. Some men opt to use progressively heavier weights for anywhere from months to years, which act as tissue expanders.

V–Y Advancement Flap

In order to extend the skin on the border area between the penis and the pubic area, V–Y plasty, Z plasty, and multi-Z plasty are some of the popular methods used. At the root of the phallus, the skin can be elongated with V–Y plasty. The penopubic skin may sometimes prevent further extension of the penis, and in these cases, skin flaps are created in an attempt to advance the penopubic skin onto the penile shaft.

The most commonly performed procedure seems to be the inverted V–Y advancement flap technique, which was first described by Long in 1990 in China [27]. Long (1990) performed suspensory ligament incision and V–Y plasty on patients who had small penises. Furthermore, Ross and Lissoos (1994) improved on this method by attaching the penis to the lateral part of the scrotal flap and the suspensory ligament was subjected to plasty, allowing easy migration of the graft and making the procedure simple and less time consuming [19].

With regard to the V–Y advancement flap technique, under local anesthesia, the outlines of the incisions are marked at the penopubic junction or proximal to the penopubic junction. These outlines are made in the form of an inverted V. After making a skin incision, the subcutaneous fat is split. This flap is mobilized with caution to preserve blood supply so as to not devascularize the flap. One stitch joins the subcutaneous fat at the tip of the V with that on either side. The skin is not sutured at the tip of the V. Monofilament 4-0 nylon suture is used to close the Y skin seams and

should remain in place for 2 weeks to prevent wound dehiscence, which is a rare occurrence. We recommend that the ideal angle of the "V" be approximately 60°. Using an angle greater than 60° can restrict the length; however, an angle too small can compromise blood supply, often causing healing problems at the Y junction owing to poor blood supply. Because V–Y advancement flaps are distally based flaps, flap viability may be compromised when the blood vessels to the flap are damaged, possibly leading to distal flap loss, poor wound healing, and dehiscence [28, 29]. A large V–Y advancement flap based distally at the penopubic junction is not recommended because it often results in a deforming, dorsal hair-bearing hump at the base of the penis, large "dog ears," giving the appearance of penile shortening, especially in patients with a relative penoscrotal transposition or a thick suprapubic fat pad [30].

One shortcoming of V–Y plasty is the possibility of penile edema or skin necrosis. Scrotalization of the penis might occur, making the penis look unnatural and leading to excessive scar contracture. Because advanced flaps are thicker than normal penile skin and are hair-bearing tissues, most of these flaps transform to a hump-like, unattractive hair-bearing tissue that covers the penis, resulting in pubic deformation. This flap could result in the penis being buried in the scrotum, thereby, paradoxically, creating a shorter penis and dog ears on the scrotal margins. The skin advancement can also lead to phimosis. Formation of a thick, hypertrophic scar, most prominent at the apex of the Y plasty, is another frequent complaint [31].

Complications After Surgery

In order to reduce the likelihood of complications, surgeons, especially less-experienced surgeons, should pay attention to the involved procedures. Complications that might occur after surgery are penile edema, wound dehiscence, infection, hematoma, downward erection angle, loss of sensation, and penile shortening. However, the likelihood of such complications can be minimized by selecting proper surgical methods. Penile shortening is a major complication, usually resulting from the freely hanging penis reattaching to the pubic bone located higher on the corporal bodies. This likelihood of this complication can be minimized by the placement of surrounding soft tissues, fat tissues, polytetrafluoroethylene, Gore-Tex, and other artificial materials, as described previously.

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Penile Lengthening: Z-Plasty

18

Ki Hak Moon

Introduction

Penile lengthening techniques are composed of release of the suspensory ligament and penopubic skin advancement. Penopubic skin flap has been used in an attempt to elongate penopubic skin. These procedures are performed to advance full skin covering of the extended penis. Inverted V-Y advancement flap and z-plasty have been mainly used to elongate penopubic skin.

Z-Plasty

Z-Plasty is a procedure which involves the transposition of two interdigitating triangular flaps. The basic Z-plasty is composed of a central limb incision and two lateral limb incisions which form a "Z." The lengths of the three limbs and the angles formed between the central and lateral limbs are equal. The incisional pattern creates two triangular tissue flaps that are transposed, changing both the length and orientation of a wound or scar. Z-plasty is used to redirect scar into relaxed skin tension lines and natural skinfold to improve cosmetic or functional outcome. Also, Z-plasty lengthens the initial wound or scar. The amount of lengthening is related to the angle between the central and lateral limbs (Table 18.1).

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The 60° Z-plasty is most commonly used because it provides the optimal balance between lengthening and ease of closure. Z-plasty mobilizes adjacent tissue to close skin defects that might otherwise have required a skin graft (e.g., deepen finger digital web spaces or correction of syndactyly), lobular transposition in congenital microtia (i.e., small ears), vaginal reconstruction, and management of pilonidal cysts [1–3]. Z-plasty realigns tissue (e.g., male cervicoplasty) and can be used to shift topographical structures (e.g., nasal ala in craniofacial clefts, release epicanthal folds in the Asian eyelid).

The classic Z-plasty has two flaps of equal angle and length (Fig. 18.1). Traditionally, these flaps are raised at 60° as this angle offers the best balance between elongation in the axis of the scar and the creation of tension forces pulling perpendicular to the scar [4].

Z-plasty has been used in penile lengthening surgery which can give adequate skin advancement to the penis during erection after suspensory ligament dissection. In general, penile lengthening surgery can get a mean 1–2 cm penile length gain [4, 5] (Fig.18.2).

Table 18.1 Z-plasty gains in lengths

Angle of lateral limb of Z-plasty (°)	Theoretical gain in length (%)
30	25
45	50
60	75
75	100
90	120

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Double Z-Plasty

Double Z-plasty (four-flap Z-plasty) is a variation of Z-plasty. A four-flap Z-plasty has two additional limbs coming off of the central limb (Fig. 18.3).

This creates more length for a given angle compared to the classic Z-plasty and is useful in releasing severe scar contractures in areas of otherwise normal flexion, such as the neck. However, this procedure is not frequently used in penile lengthening.

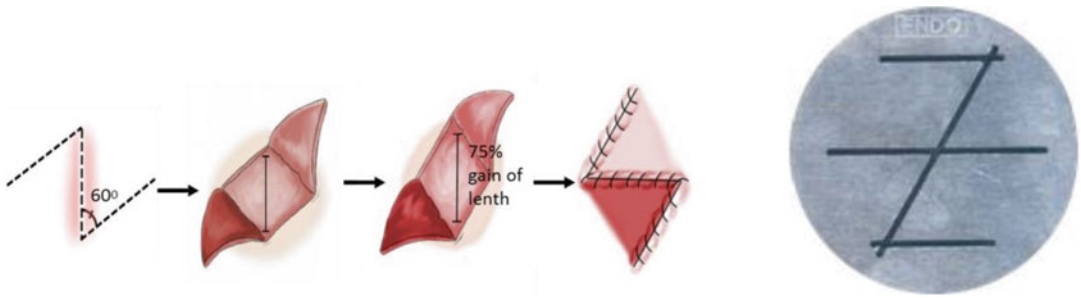

Fig. 18.1 Technique of classic Z-plasty

Fig. 18.2 Penile lengthening procedure: through a suprapubic Z-plasty incision, advancement of penopubic skin was achieved

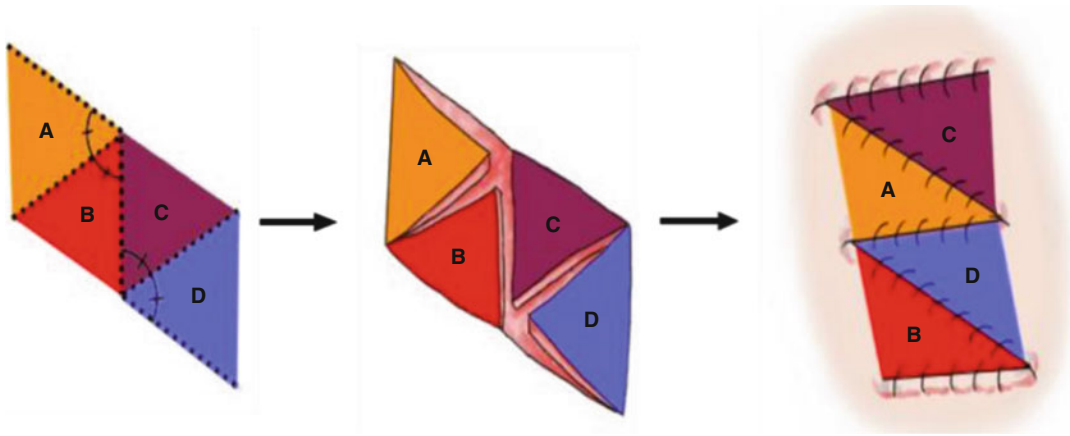

Fig. 18.3 (Fig. 18.1) Technique of double Z-plasty

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Penile Disassembly and Glans Detachment

19

Jin-Hong Kim

Introduction

There is a debate between continents on the globe regarding the best surgical approach method for Peyronie's disease (PD): how to elevate the neurovascular bundle (NVB) and how to properly access the tunica albuginea layers of the penile erectile body. Tom Lue of San Francisco, California, USA, advocates a medial approach. But from 1982, Edoardo Austoni of Milan, Italy, proposed spongious-cavernous disassembly through a lateral approach [1, 2]. For radical plaque surgery and subsequent relaxing plaque surgery after Paulo Egydio's principle, Austoni's proposal has given surgeons more inspiration during recent decades [3]. However, Lue's technique is used with gratitude for mild and moderately severe PD and congenital ventral curvature treatments.

Before the clear descriptions of the penile venous anatomy of the multiple drainage systems in the NVB by Gen-Long Hsu and Cheng-Hsing Hsieh of Taiwan, the deep dorsal vein system (DDV) was considered as single venous drainage system of the NVB from the glans [4]. During medial approach technique of NVB elevations, unexceptional surgeons would face a challenging emotional question before gaining clear knowledge about what lays ahead: sacrifice which of the dual axial venous drainage systems from the glans – through the urethra and DDV of the NVB.

The novel technique of penile disassembly is not only an essential surgical method for Peyronie's disease, but is also crucial for all kinds of genitourinary reconstructions: from congenital to acquired diseases, from pediatrics to adult urology, from intersex to transgender surgeries, and from penile cancer to lengthening surgeries. However, special caution should be paid when selecting patients for disassembly techniques. Patients who have had previous surgeries should be checked using duplex Doppler ultrasound studies to determine whether they have a deteriorated axial blood supply to the glans because of an injured NVB. Those patients will have a single blood supply through the urethra to the glans, and when it is neglected it can result in flap loss.

Sava Perovic was regarded as a prophet of penile disassembly technique and flap surgeries in the field of genitourinary reconstructions. His career started in the field of pediatric urology and he widened application of penile disassembly techniques to hypospadias, epispadias, severe penile curvature, glans tilt, intersex, and gender reassignment surgeries [5]. His contributions to adult urology using this novel technique were:

- Creation of a neoglans by using inverted urethral tube after glans loss due to penile cancer surgery
- Real penile lengthening by tunical grafting with circular incisions

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- Multi-grafting on multi-relaxing incisions on multidirectional curvatures and narrowing because of PD or corporeal fibroses, with or without simultaneous penile prostheses implantations [6]

Surgical Techniques

Perovic defined penile disassembly as having three stages: separation of all the penile entities, repair of the anomaly, and reassembly of all the penile entities into their normal relationships.

The first stage of operative techniques on dorsal side of penis can be explained in a step-by-step manner as follows (Figs. 19.1 and 19.2):

1. Make sub-coronal skin incisions, degloving the penile skin with dartos layer by sub-dartos dissection, to reveal NVB and urethra, up to round ligament dorsally and crural diversities ventrally.
2. Elevate the NVB through bilateral or unilateral paraurethral longitudinal incisions:
   A. Dissection and division of circumflex veins allow approach to the albuginea (these step can be performed by electrocauterizations).
   B. Blunt dissection of NVB from tunica albuginea.
   C. Division of the "triangular ligament" allows approach to the cavernosal tips.
3. Mobilize the urethra (order of step 2 and 3 can be switched).
4. Divide the glans cap from the corporal tips (step 4 is not always necessary).

Structure of Glans Cap and Tips of Corpora

The triangular ligament is also known as distal ligament of the glans. Gen-Long Hsu et al. described the distal ligament in human beings as similar to the os penis of a dog. Type I collagen is also a major component, with type III collagen as an interlocking ingredient without osteocytes or chondrocytes. The distal ligament (arrow) within the glans penis is obvious and should be regarded as a ligamentous structure rather than sinusoidal only. The distal ligament is an aggregation of the outer longitudinal layer of the tunica albuginea and acts as a buttress for the glans penis (Fig. 19.3a) [7].

Panoramic views around the corporeal tips after dissection of triangular ligament show placement of the urethra's fossa navicularis in the groove between the tips of the corpora on the ventral side. The cleft on the tips of the corpora is the real location of the triangular ligament, which is extended on the dorsal side of the corporeal tips (Fig. 19.3b–d). Based on the clear dissection plane on serial views, this is quite separated from the tunica albuginea layers. The triangular ligament, the homologous structure of the os penis in other mammals, should be understood surgically as aggregation of the inner longitudinal layers of the Buck's fascia. Its extension at the distal one-third of the dorsal aspects of the penis during neurovascular bundle elevations can be witnessed in some cases.

Applications of Penile Disassembly Technique in Adulthood

Proper understanding of the philosophy of penile disassembly technique is essential for good surgical results. That is the reason we must acquire a basic knowledge of flap surgeries. After penile disassembly, prepared individual penile entities are considered as different flaps which have individual axial vascular supplies. For example, the NVB, actually the inner and outer Buck's fascia layers, can become a vascular bed for grafting materials of sub-dartos implantations during penile girth enhancement surgeries from the bottom side or can become vascular beds for substitution tunical grafts from the upper side.

The urethral structure is also in same situation during hypospadias and epispadias repair. It can become a vascular bed or a target of repair at the same time. The glans has dual blood supply from the NVB dorsally and the urethra ventrally. In

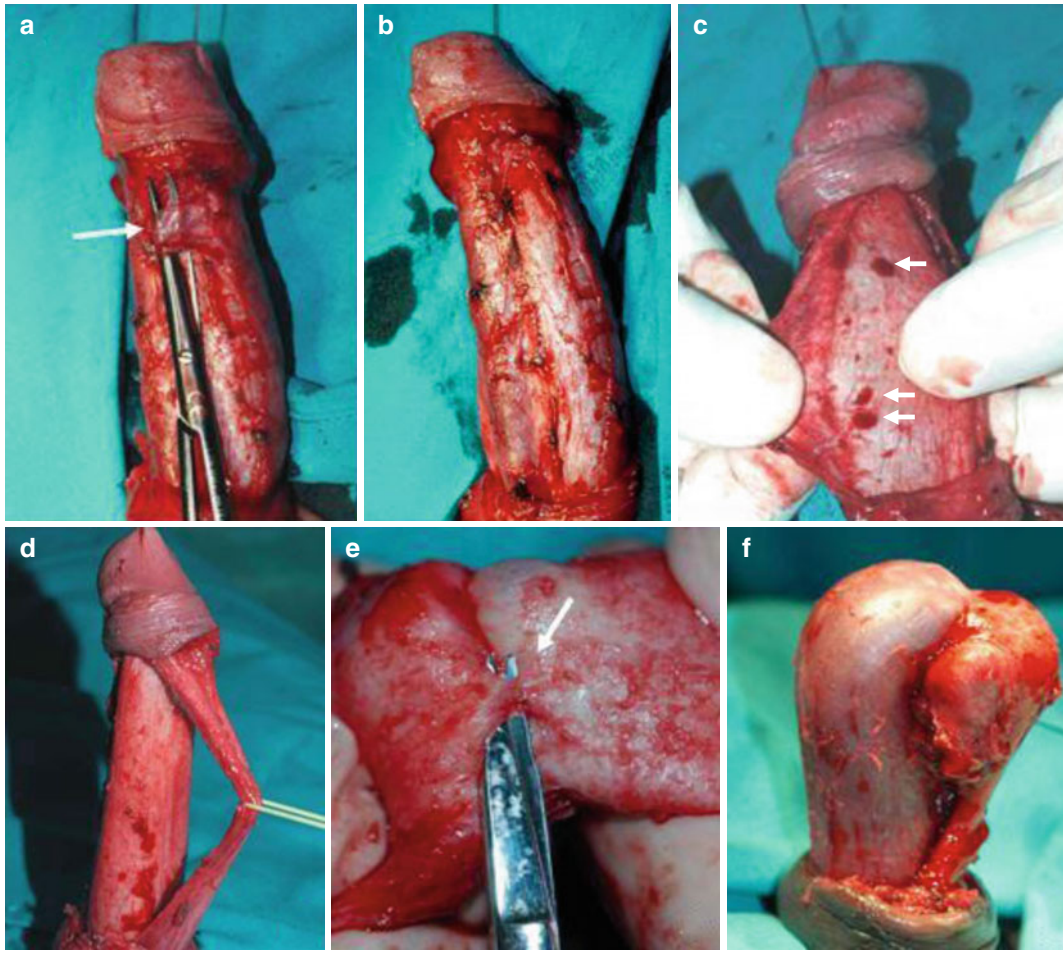

Fig. 19.1 Penile disassembly technique stage one – part one: Neurovascular bundle elevations and triangular ligament division. (**a**) Identification and dissection of circumflex veins (*arrow*). (**b**) Division of circumflex veins by electrocautery. (**c**) Elevation of NVB from tunica albuginea by blunt fingertip dissections. Cut surface of perforating veins are visible (*arrows*). (**d**) Isolation of thin NVB with vessel loop. (**e**) Division of "triangular ligament" (*arrow*) on the dorsal midline of corporeal body. (**f**) Dissection extended to corporeal tips

some cases, we can sacrifice one of them, mainly the urethral side.

Peyronie's Disease

Patients with Peyronie's disease and erectile dysfunction (ED) who are nonresponsive to oral or injectable treatment are candidates for penile prosthesis implantation. Usta et al. reported the long-term results of surgical treatment for PD, showing that penile prosthesis implantation and curvature correction with bovine pericardium graft added no risks of complications as compared to prosthesis implantation surgery alone [8]. Various kinds of grafting materials, including autologous tissue grafts, were used for correcting curvatures depending on sociogeographical availabilities on their countries [9].

Repair of the penile bending phenomenon and simultaneous restoration of original penile length in corporeal fibrosis cases was started by Perovic et al. [10]. He made complete circular incisions and used circumferential grafts to construct

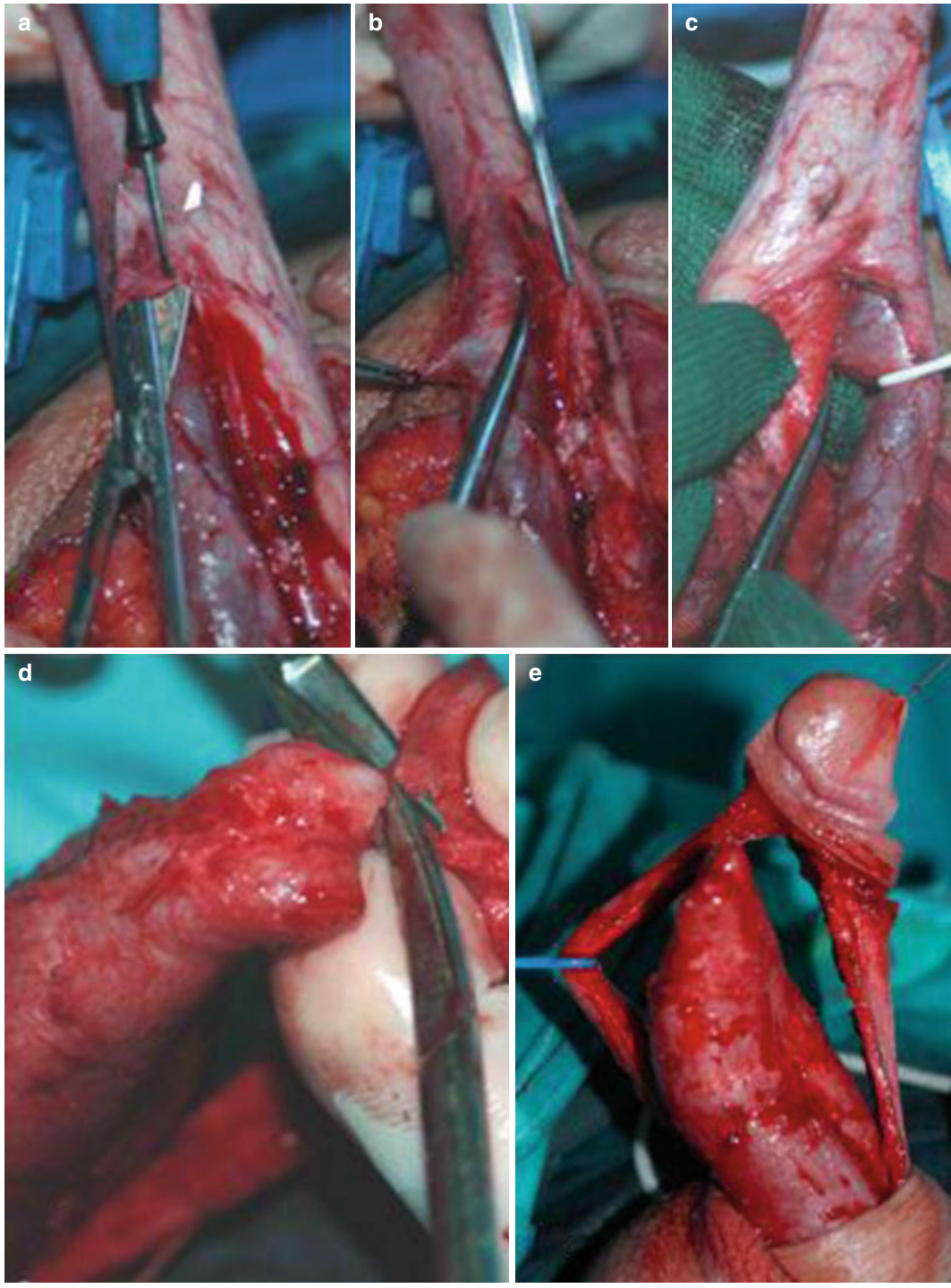

Fig. 19.2 Penile disassembly technique stage one – part two: Urethral mobilization and glans detachment. (**a**–**c**) Urethral mobilization by bidirectional approach up to urethral groove in the median line of corporeal body, enabling separation of the urethra from corporeal body. (**d** and **e**) Complete division of glans cap from corporeal tips

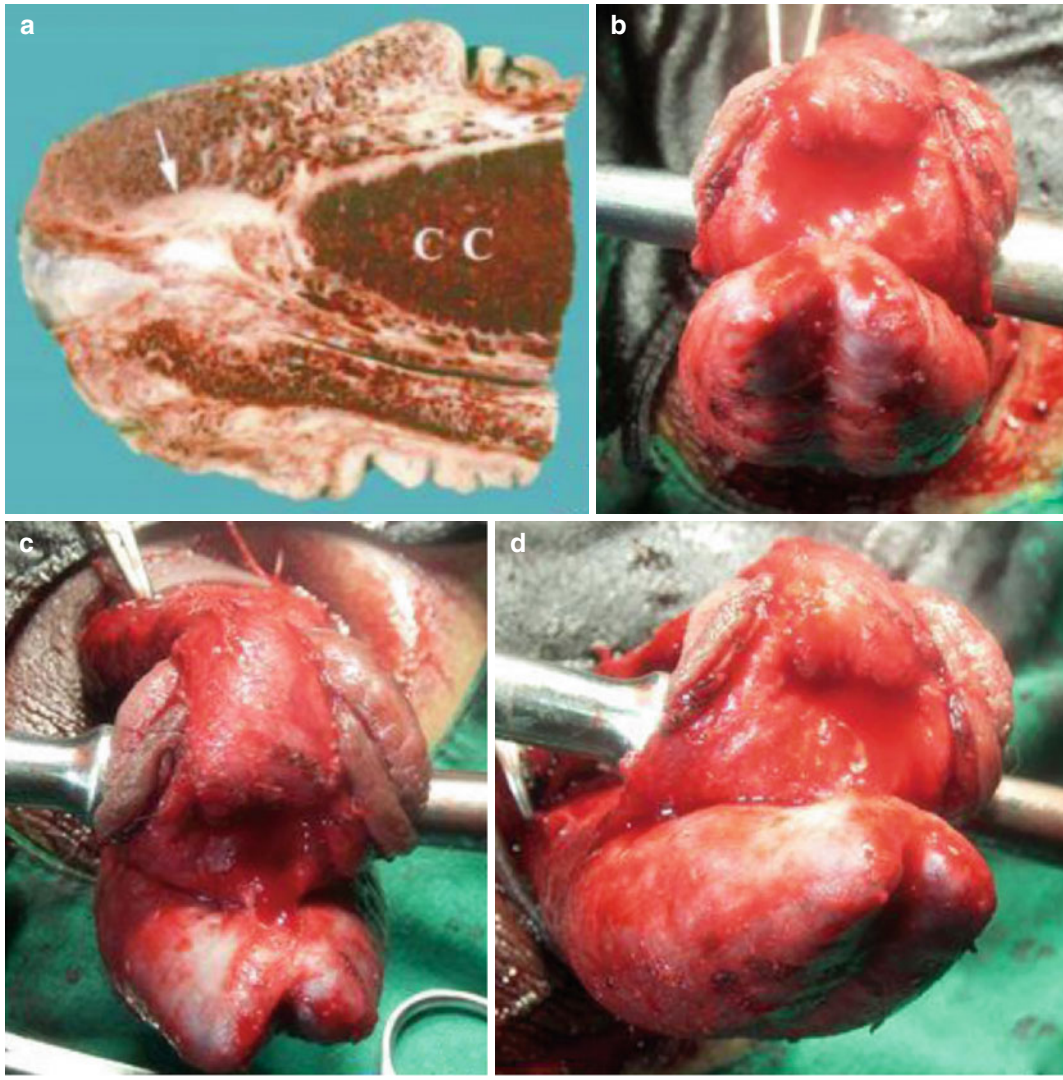

Fig. 19.3 Structure of glans cap and tips of corpora. (**a**) The triangular ligament is also known as the distal ligament in the glans (*arrow*). The distal ligament acts as a buttress for the glans cap [7] [get permission for usage from authors]. (**b–d**) Panoramic views around the corporeal tips after dissection of triangular ligament from the ventral side. The widened groove between the tips of corpora on ventral side is the base placement of the fossa navicularis of the urethra. The cleft between the tips of corpora is the real location of the triangular ligament, which is extended on the dorsal surface of the corporeal tips

enough space for accepting properly sized cylinders of the penile prosthesis at the operating theater in Italy together with Paulo Egydio. It is remembered as the launch of international multicenter trials on corporoplasty for penile augmentations – functionally real penile lengthening. This group of senior Master Class collaborators continued to develop new innovative technologies and methodologies after the passing of Perovic in 2010 [11, 12] (Figs. 19.4 and 19.5).

Corporeal Fibrosis and Penile Shortening: "Djinovic Method"

There are two categories of artificial grafting materials based on origin: biologic and synthetic matrices (scaffolds). Use of artificial graft materials reduced operating time by eliminating harvesting autologous grafts, such as saphenous vein, dermis, and buccal mucosa, and overcame the limitations of graft size. Biologic origin

Fig. 19.4 Peyronie's disease with 90° dorsal curvature and axis rotation, create visual illusions of lateral curvature. (**a** and **b**) Preoperative views after pharmaceutically induced erection in 71 years old patient. (**c**-**f**) Following Egydio's principle, a single, incomplete relaxing incision and grafting were done together with malleable penile prosthesis implantations. Grafting material was allograft dermal matrix (MegaDerm®, L&C BIO, South Korea). (**g**) Outcome after 6 months

matrices have good tissue affinity and tissue incorporation characteristics. But bed tissue rejection because of limited inosculation of vasculatures is also an inevitable characteristic of this type of material, especially when the graft size is big.

Several kinds of synthetic graft materials have been used for tunical substitution. The most commonly used one is ePTFE (extended polytetrafluoroethylene; Gore-Tex®). The limitation of ePTFE in the case of inflatable penile prosthesis implantations is insufficient compliance during inflation and deflation of devices. Rados Djinovic uses polypropylene (PP) mesh in these cases. Because PP mesh is made of woven fibers, the big pore size gives enough compliance and elasticity, easy drainages of collected fluids, as well as good tissue ingrowth effect (Figs. 19.6 and 19.7).

Micropenis: "Real Penile Lengthening" without Penile Prosthesis Implantation

Strict and narrow inclusion criteria should be used, and meticulous preoperative evaluation of patients must be performed during selection of candidates for "real penile lengthening" without penile prosthesis implantation after complete multiple circular incisions and circumferential grafting because expanding the volume of erectile space can result in erectile dysfunction. Special care and respect must be concentrated on preserving undamaged cavernosal arteries and the structural stability of the intercavernosal septum. A suitable candidate must be healthy, young, and with no risk of erectile dysfunction, unless it would be better

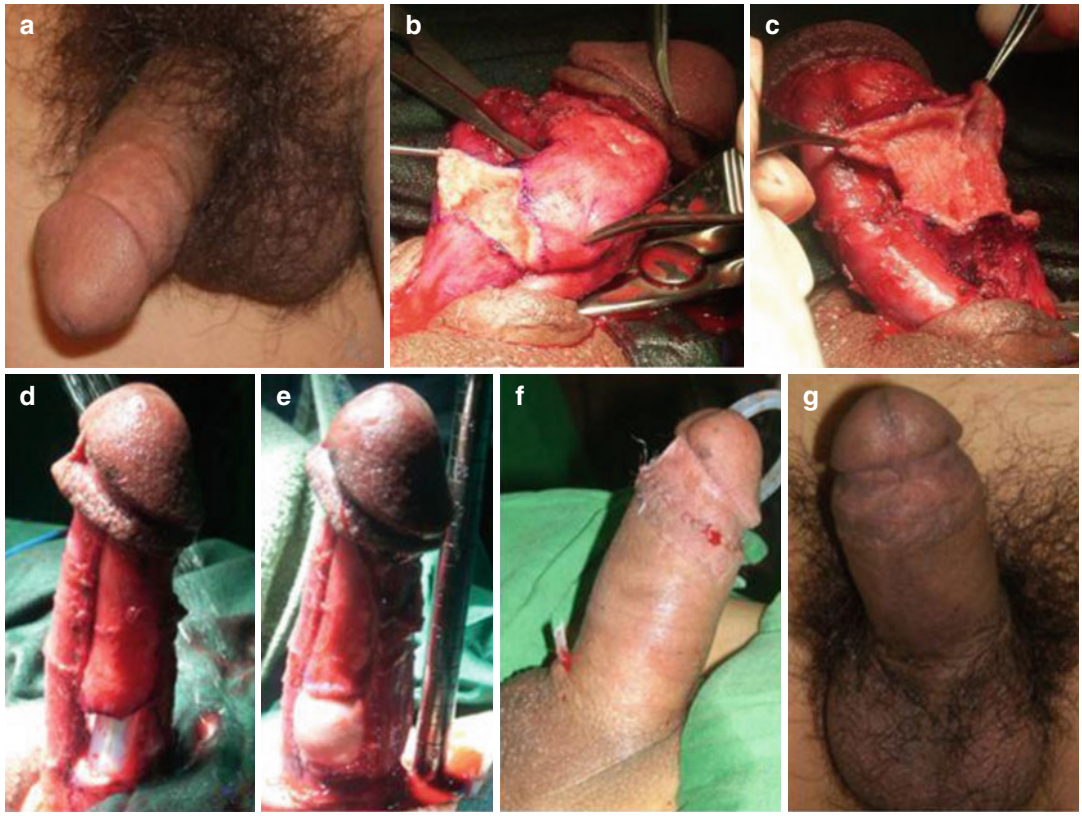

Fig. 19.5 Peyronie's disease with 45° ventral curvature and erectile dysfunction. (**a**) Preoperative view after pharmaceutically induced erection in 51 years old patient. (**b**-**f**) Following Egydio's principle, incomplete single relaxing incision and grafting were done together with malleable penile prosthesis implantations. (**g**) Outcome after 4 months

to implant penile prostheses simultaneously. In such cases, the candidate must give specific informed consent about the need for penile prosthesis implantation surgery or the possible need in the near future. Patients tend to be naturally aware with no need for further explanation that axial rigidity of penis is one of most important factors impacting on sexual abilities and satisfactions, second to appropriate and acceptable penile size.

Because NVB elasticity is limited, the length gain goal should be settled at no more than 3 ~ 4 cm. If lengthening exceeds this natural limitation, deteriorated vascularities toward the glans may result in loss of the glans, especially when over-sized penile prostheses are implanted. Postoperative physiotherapy using a vacuum device is encouraged to prevent penis contracture (Fig. 19.8).

Congenital Ventral Curvature

"Tunical attenuation techniques" may provide asylum between the two major conventional surgical modalities to treat severe congenital ventral curvature problems: dorsal tunical plication and ventral tunical grafting techniques. The bright side of tunical plication technique is the ease of the procedure. The dark side is the theoretical and practical unavoidability of penile shortening when the shorter-side penile length is assumed as the surgical outcome. Therefore, the usefulness of dorsal tunical plication technique is limited to non-severe cases. The benefit of tunical grafting technique is that it empowers the surgeon to achieve longer-side penile length as the surgical result. However, this technique is a difficult, time-consuming, and expensive-material-dependent art.

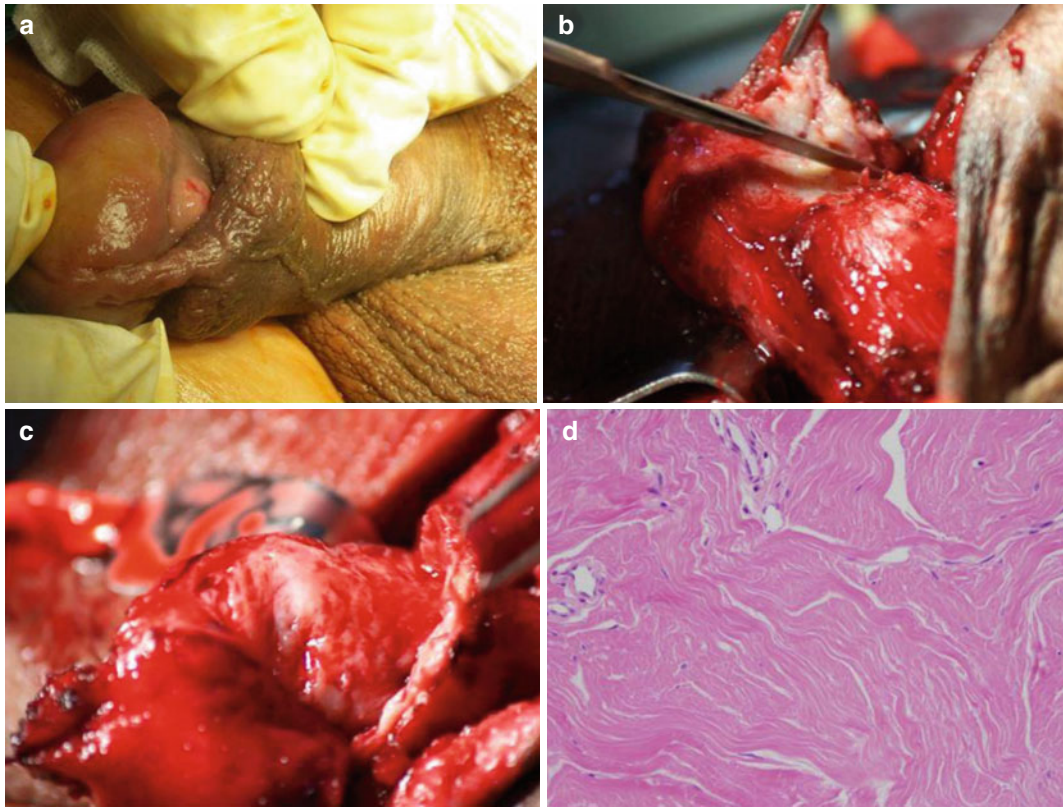

Fig. 19.6 Corporal fibrosis and penile shortening part one: (**a**) Penile prostheses were removed 18 months before surgery. (**b** and **c**) Separation of tunica albuginea from fibrosis and scar transformed erectile body of corpus cavernosum. (**d**) H&E staining of corpus cavernosum showed disappearance of sinusoidal structures and infiltration of fibroblasts (×200)

The meaning of attenuation is elongation of tunica albuginea by removing the continuity of outer longitudinal fibers of it using cold knife. After penile disassembly with preserved attachment of the glans, relaxing incisions are made by scalpel on the outer longitudinal fibers of the tunica albuginea in absolute respect of erectile tissue and inner circular layer of tunica albuginea. When the incision lines reach the ventral groove, the line must cross the groove. At this moment, we can detect a bursting sensation transferred through the scalpel and finger tips.

These so-called tunical attenuation techniques are best, when it is performed by pharmaceutically induced artificial erections without tourniquets. Contrary, and superior to using dorsal "tunical plication methods" solely, ventral "tunical attenuations" avoid penile shortening after curvature correction.

During penile reassembly, wound irrigations using an anti-adhesive agent such as 4 % icodextrin solution (Adept®, Baxter) and infiltrations of 1 % sodium hyaluronate gel (Hyruan®, LG life science, South Korea) in the Buck's fascia layers of the NVD, and the urethra should be regularly performed to prevent immediate postoperative wound contractures and to control minor bleeding. After complete wound healing, 6 months of postoperative physiotherapy with a vacuum device is an essential recommendation for preventing delayed postoperative scar contracture and eventual penile shortening. Abovementioned intra- and postoperative treatment tips are critical information to ensure good quality of life of the patients (Fig. 19.9).

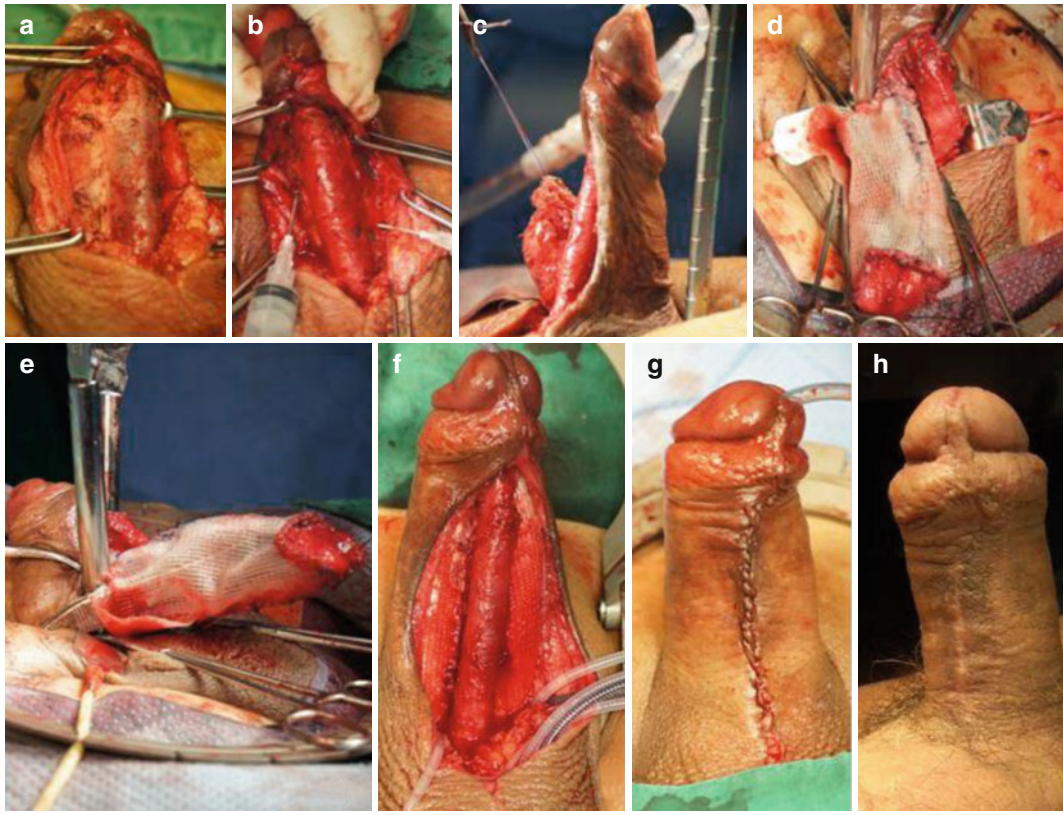

Fig. 19.7 Corporal fibrosis and penile shortening part two: "Djinovic method" of inflatable penile prosthesis implantation with tunical substitution using polypropylene mesh in the case of severe corporal fibrosis, reproduced by author. (**a**) Ventral longitudinal midline penoscrotal incision was made from frenular area to midscrotum, to reach bulbous urethral region. (**b**) To facilitate NVB elevations in continuity with Dartos' fascia layer, antibiotic saline solution infiltration into fibrotic cavernous space was performed using 16 G needles in 10 ml syringes. This procedure aided hydrodissection between tunica albuginea and Buck's fascia layer by means of water seepage through perforating veins of the tunica albuginea into the inner layer of Buck's fascia. (**c**) After completion of disassembly, disproportionate elasticity of penile entities was identified. After full stretching, there was a gap of more than 5 cm in length between fibrotic corpora and other penile entities. (**d** and **e**) During preparation of PP mesh grafting, 28 Fr. Metallic Sounds were placed inside of the crura to prevent bleeding. More than 80 % of the tunica albuginea surface was used for creating corporeal tips and the urethral plate. These tricks were possible after demolition of stony-hard cavernosal fibroses. (**f**) 16 cm AMS 700 CX® cylinders were implanted inside of the PP mesh grafts. (**g**) Closure of wounds. (**h**) Outcome after 2 months postoperatively

Glans Tilt

When the pathologic lesions are located very near or under the glans region, there is no choice but penile disassembly technique to reach the lesion and correct it. In the case of re-sculpturing of penile disproportions, relocation of penile entities is possible by using penile disassembly techniques (Fig. 19.10).

Penile Cancer: Organ-Preserving Surgery

Preserved values after organ-preserving surgery at low-stage penile cancer confined to the glans are "length of erect penis" and "self-esteem." And patients can be saved from unavoidable multistaged surgeries for reconstructing penile shape and functions they are forced to endure by

Fig. 19.8 Micropenis: real penile lengthening without penile prosthesis implantations after complete multiple circular incisions and circumferential grafting (Courtesy of Prof. Dmitry Kourbatov, Moscow, Russia), (**a** and **b**) The patient was 26 years old with hypospadias, micropenis, hypogonadism, and testis atrophy. (**c** and **d**) Two separated complete circular incisions and grafting were performed using allograft tensor fascia lata from a local manufacturer in Ufa, Russia. (**e**) Outcome after 1 year

choosing traditional partial penectomy solutions. Exposed neoglans surface of former urethral lumen gives ease of access for cancer recurrence follow-up (Fig. 19.11).

Complications

For good flap survival, avoiding damage to the axial blood supply is of critical importance because flap necrosis is the most drastic complication of flap surgeries to avert. Flap loss can happen immediately or later for various reasons. Immediate loss means damaged vascular systems during surgery, much shearing stress and tension on the NVB during healing, hematomas collection between layers, inadequate drainage of fluid collections, and/or too tight compressive wound dressings. Delayed flap loss would be the result of infections, cicatricial changes around venous drainage pathways, pressure ulcer, and/or autoimmune disease such as Behcet's disease (Fig. 19.12).

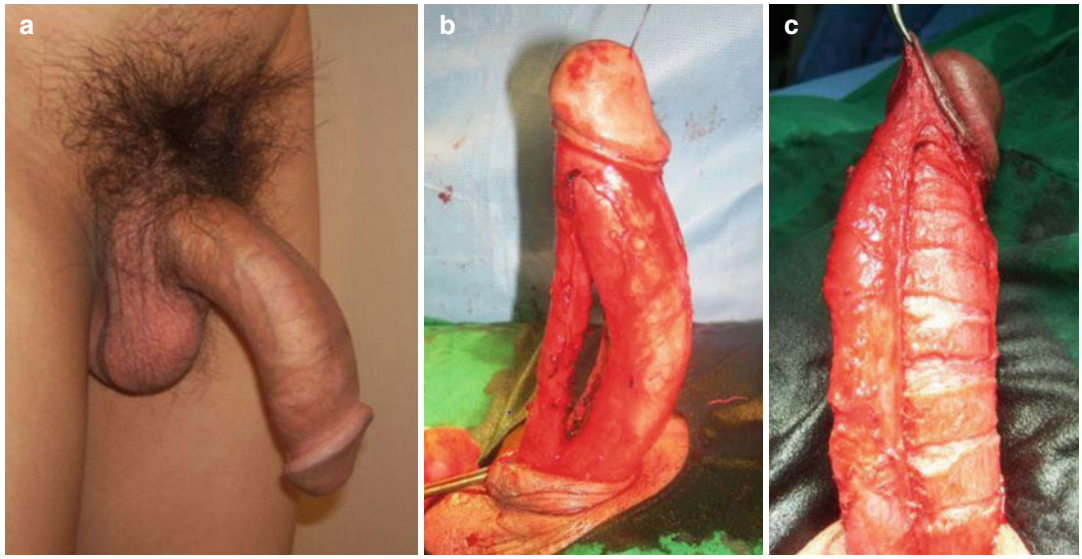

Fig. 19.9 Congenital ventral curvature approaching 90°. (**a**) Presurgical view during full erection. (**b**) After incomplete disassembly preserving glans attachment, (**c**) relaxing incisions were performed by scalpel on the outer longitudinal fibers of tunica albuginea in absolute respect of erectile tissue and inner circular layer of tunica albuginea. These so-called tunical attenuation techniques are best performed by pharmaceutically induced artificial erections without tourniquets

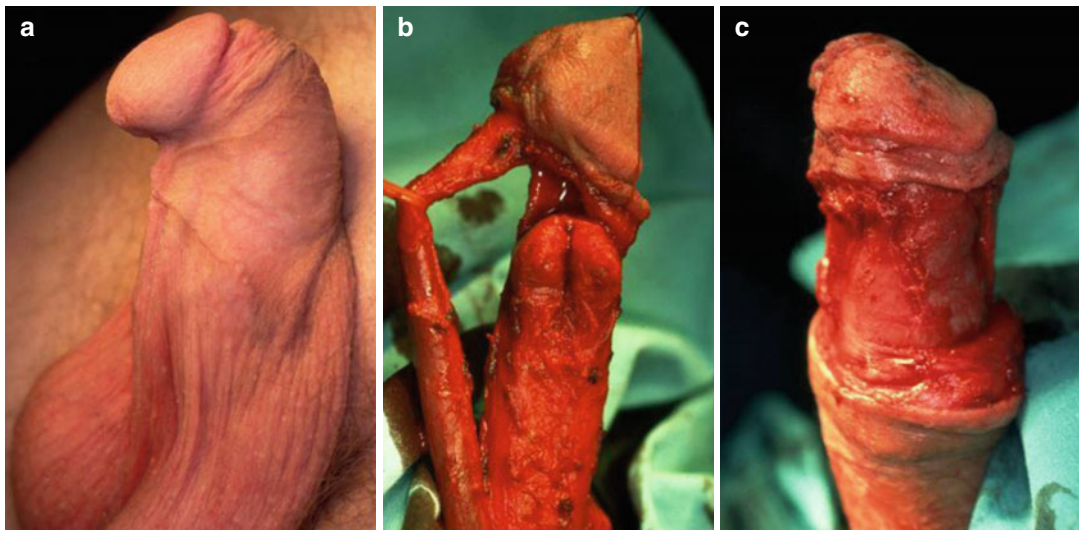

Fig. 19.10 Glans tilt; (**a**) Chordee without hypospadias. (**b**) After penile disassembly and correction of corporeal bending at the tips, (**c**) glans was relocated to the rightful position (Courtesy of Dr. Rados Djinovic, Belgrade, Republic of Serbia)

Sava Perovic et al. reported that in 52 cases of epispadias repair results, there was no glans necrosis or sensory loss after complete penile disassembly. Complications were confined to the urethra in four cases and remaining curvatures in two cases. These results suggest that insights into the anatomical features of the epispadiac penis can have a significant impact on surgical outcomes [13].

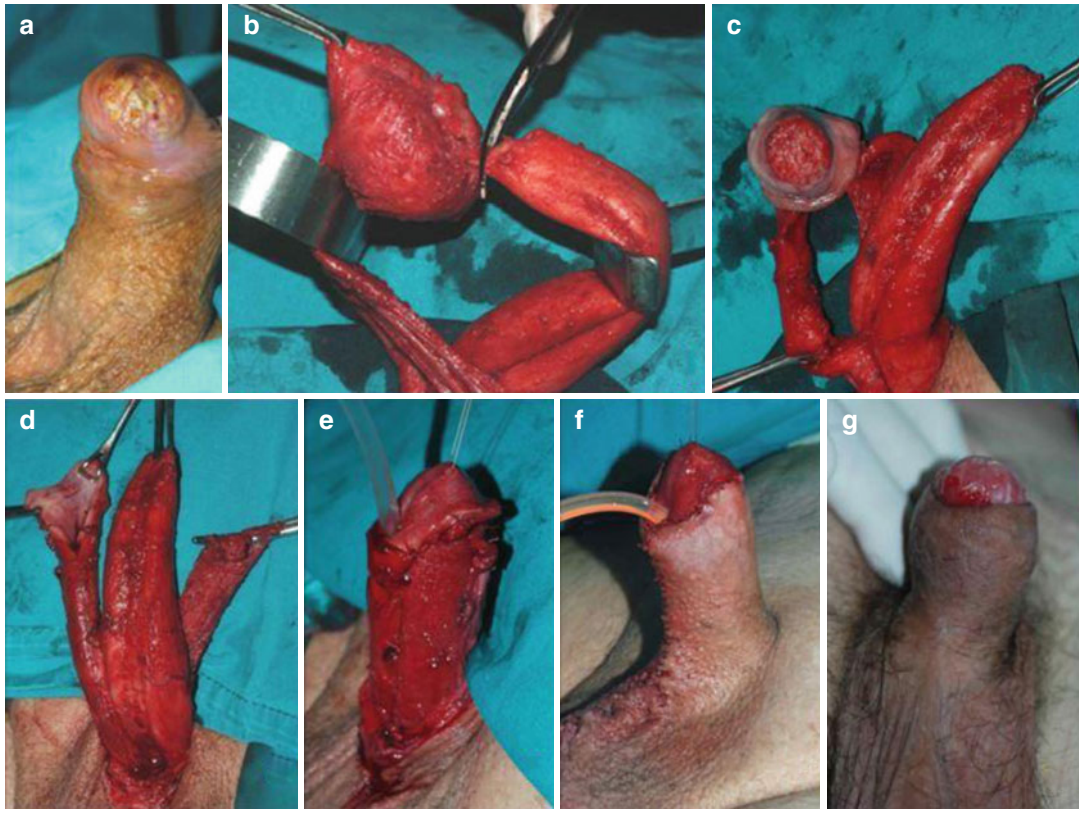

Fig. 19.11 Organ-preserving surgery at low-stage penile cancer (Courtesy of Dr. Rados Djinovic, Belgrade, Republic of Serbia). (**a**–**c**) After penile disassembly, glans was removed. (**d**) Urethral flap was created for extension and relocation. (**e**, **f**) Stage of glans reconstruction using urethral flap. (**g**) Outcome 2 months after surgery

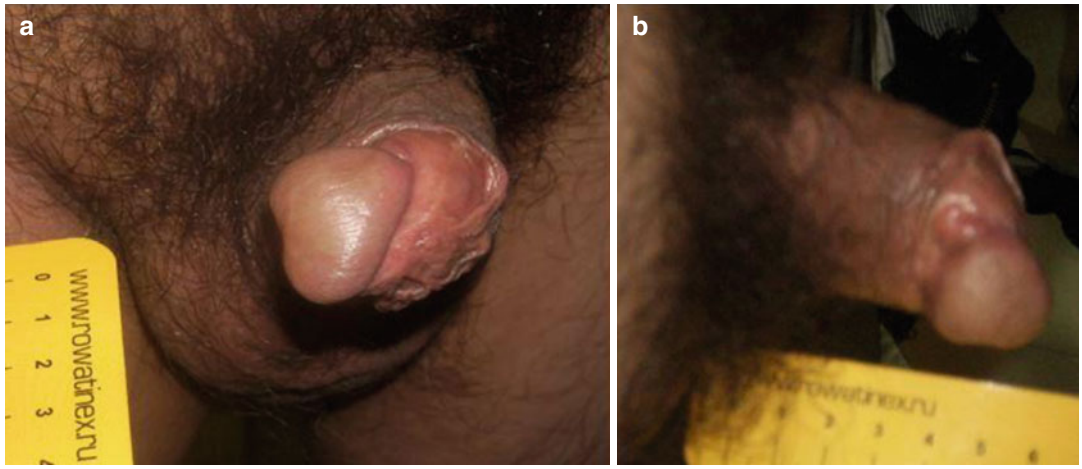

Fig. 19.12 A 51-year-old patient remembered left hemi-glans loss at age 16, during healing period of the third repair of epispadias. (**a**) Frontal view on erect status. (**b**) Above view on full erection. Axial rotation of penis 45° counterclockwise and right lateral curvature at the proximal penile root are observed, together with lateral deviation of remaining right hemi-glans

Summary

Penile disassembly technique and its applications enable significant improvement in reconstructive genital surgery. The benefits of penile disassembly greatly overweigh the risk of complications in very challenging cases. Proper knowledge and experience using these techniques and penile anatomy are essential to good surgical outcomes. This investigative technique should be considered on an individual basis, also considering other techniques. Treatment can be effective and safe only in specialized surgical teams.

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Penile Traction Therapy (Penile Lengthening Device)

20

Kweon Sik Min

Introduction

As a result of increased concern about penis size of the men with even normal penile size recently, penile augmentation procedures for these men have increased gradually. These procedures were performed in primary private clinic rather than in tertiary university hospital. However, there were a few data and reliable evidences for penile augmentation or lengthening surgery published in journals compared to increased surgical cases recently. Because of lack of evidences and reckless procedures widespreadly to men with normal penis size, International Society of Sexual Medicine recommended that a series of penile augmentation phalloplasty was not recommended for men without abnormality of the penis. Additionally, data associated with penile augmentation surgery showed serious complications including troublesome anatomical deformities and erectile functional changes after penile augmentation or lengthening procedures. The incidence of complications or sequelae was reported 45 % in post procedural skin infections and 60.3 % in angled or anatomical deformities of penile shaft, pain on op site, and curvature-like erectile change, although some report found no serious complications. Therefore, it was necessary to develop less invasive techniques, which would show even less effectiveness. In this regard, mechanical penile traction such as using penile traction device attracted attentions for much less invasiveness compared to surgical procedures. Girth enhancement surgery by any type of graft is easier to reach favorable results rather than penile lengthening surgery [1]. It might be expected that surgical procedure would show excellent outcome compared to medical lengthening methods. However, since it has been considered that successful gain in penile length was 1–2 cm [1], length gain from medical penile traction therapy is similar with outcome from lengthening surgical procedure in many data. Therefore, although lack of rationale and evidence data of efficacy for traction devices remained as problems to be solved, these devices would be one of the good alternatives for men seeking penile elongation.

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Rationale of Penile Traction Therapy

Physiological Rationale for Penile Lengthening

The concept of penile tissue expansion by mechanical traction is not a new idea. Penile traction therapy is an extension of tissue expansion technology which has been conducted for a long time in plastic, orthopedics, and reconstructive surgery. Although traction therapy has been used in plastic, orthopedic, and maxillofacial surgical applications

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for many decades, the action mechanism of penile traction therapy has not been clearly explained. Tissue growth occurs as a result of tissue adaptation in response to application of chronic traction. The possibility of an effective elongation of body structures after applying prolonged and progressive tension forces was suggested from generation of new tissue after applying skin expanders in plastic surgery [2]. This process is thought to be cellular proliferation like the process of distraction osteogenesis resulting from bone lengthening procedures by using traction [3, 4]. The background of cellular proliferation by mechanical traction is a documented response of human viable tissue to physical traction. Prolonged traction force on tissue results in an adaptation reaction at a cellular level, which thereby results in the expansion of the tissues [5]. This traction therapy has successfully been applied for some duration for different medical purposes. Each different tissue such as long bone, skin, and scar responds differently to chronic traction.

Mechanotransduction is a cellular signal transduction in response to mechanical stimuli, which resulted in modulating almost all aspects of cell function, including cell growth, differentiation, migration, gene expression, protein synthesis, and apoptosis [6]. Especially [7] demonstrated that metalloproteinase as a cellular signal which was increased in scar by applying chronic traction resulted in enhancing action of scar remodeling. Metalloproteinase, one of the enzymes degrading extracellular matrix protein, plays a major role on cell proliferation, differentiation, angiogenesis, apoptosis, and host defense. It is thought tissue growing against chronic traction is one of the tissue protective mechanisms to try to loss of mechanical strength by subsequent collagen degradation [8].

Histologically, traction has also resulted in realignment of the collagen fibers within the disordered scar parallel to the traction forces [9]. In addition, depolymerization of collagen fibers by increase in degradative enzymes induced not only weakening of the fibers by collagen degradation but the increase in newly synthesized collagen, which resulted in providing the extension of the tissue without trauma [7].

Therefore, the use of traction device is not just to stretch the tissue mechanically, but to actually induce tissue growth to make real gain of additional penile length.

Possible Lengthening Gain by Penile Traction Therapy

Men who have short penis even normal-sized penis want more elongation or enlarged girth. They have unrealistic expectation for penile lengthening gain with any procedure. Their penis was usually over 15 cm (13~19 cm), but they expected their penis would be lengthening more 5 cm after penile lengthening procedure. However, actual postoperative gaining length was 2.01 cm in average [10]. Easy surgical approach like suspensory ligament division could gain only 1.1~1.6 cm in average [11, 12]. Major penile lengthening operation which was penile assembly with autologous cartilage transplantation could gain around 2~3 cm, although some authors reported that gaining length was 4 cm at the cost of many complications even erectile function changes [13]. Phase II study for FastSize [14], one of the commercial penile traction devices in the market, revealed penis gain around 2 cm in length for 3–6 month after application of the device daily [15]. But it was reported a little or minimal adverse event as mild pain without any serious complications in the whole study period [14].

If major operation which was expected many and serious complications were not tried to be applied for great lengthening results, outcome from minor surgical procedure, which could develop unexpected results, might be similar with outcome from penile traction therapy without serious adverse events.

Background Data of Penile Traction Therapy

Efficacy of Penile Traction Therapy

Gontero et al. [15] demonstrated that after 6 month application of penile traction device for at least 4 h per day, the mean gain in penile length was significantly increased as 2.3 and 1.7 cm for the flaccid and stretched penile length, respectively. Another short-term study conducted for 3 months presented that 1.7 and 1.7 cm in flaccid and stretched penile length were gained by 4–6 h penile traction daily

[16]. A study was conducted with application of penile traction device for men with shortened penis prior to penile prosthesis implantation for up to 4 month, which was found an increase up to 1.5 cm (ranged 0.5–3 cm) in stretched penile length with traction for 2–4 h per day [17].

According to traction duration, gain in stretched penile length occurred 0.94 cm (51.6 %), 0.44 cm (24.2 %), 0.38 cm (20.9 %), and 0.06 cm (3.3 %) for the first month, for the next 2 months, for 3 months during 4–6 month, and for 6 months during 7–12 month, respectively [15]. In respect to flaccid penile length, 1.13 cm (50.2 %), 0.71 cm (31.6 %), 0.41 cm (18.2 %), and no lengthening were gained in for the first month, for the next 2 months, for 3 months during 4–6 month, and for 6 months during 7–12 month, respectively. This data revealed that traction for first 1–3 months was very important to gain a desirable penile length. Length-gaining effect was not found in traction during over 6 months. Nikoobakht et al. [16] revealed similar efficacy with Gontero et al. [15]. Penile traction for the first month and next 2 months showed 1.3 and 0.3 cm in flaccid penile length and 0.9 and 0.8 cm in stretched penile length, respectively. The possibility of reshortening of the lengthened penile length would be considered, but no regression was found till 6 months after the stop of traction therapy.

The major limitation of data about efficacy of penile traction therapy is not to be compared with control group and not to be tried in a randomized study.

Since men who applied less than 2 h per day did not gain significant length, thus, penile traction device should be worn more than 2 h per day for a desirable gain in penile length. And also the most important factor in penile traction therapy for positive outcome is patient's compliance, because traction of shorter duration or intermittent traction, especially within first 3 months, did not promise favorable results.

Adverse events of penile traction therapy were very mild because these were only occasional pain in 40 % [18]. However, the problem is that this troublesome pain decreased the compliance of the patients to keep wearing the traction device for a scheduled time as 60 %.

Oderda and Gontero [17] conducted a review which aimed to explore whether nonsurgical methods of penile lengthening may have practical efficacy. Mean gaining in stretched penile length by division of suspensory ligament from references is 1.3 ± 0.9 cm. They concluded that penile extender devices seem to be noninferior to surgical procedures.

Therefore, summing up these above data together, medical penile traction therapy is quiet compared with or noninferior to usual surgical approaches to elongate penis.

Protocol of Penile Traction Therapy

Initially, penile traction device should be applied lightly and then progressively increased in tension due to penile pain. Introduced usual protocol was 2–4 h per day with 20 min break every 2 h. Traction time could be increased progressively 4–8 h per day. Duration usually for 3–6 months (ranged from 1 month to 12 months) was more preferable because of the data according to duration of traction.

This can be applied for men with Peyronie's disease with especially shortened penis due to penile curvature in both acute and stable stage. In acute stage, the penis can be stretched for 2 h per day, but in stable stage without pain, longer time traction as 4–6 h per day could be performed minimally for 6 months [14]. It also could be applied with or without other medical therapy as injection therapy with verapamil or other medications. The device also could be applied to gain penile length before penile prosthesis insertion. In that case, the device can use 2–4 h per day for a little bit short time as 2–4 months. Even in short duration, it resulted in average gain of penile length as 1.5 cm (0.5 ~ 3 cm) in 70 % [18].

Girth Enhancement by Penile Traction Therapy

Change in rigidity after penile lengthening procedure could be developed in men whose penile lengthening was achieved enough without girth enhancement because of the weakness for buckling force due to long penis compared to girth. Therefore, they would feel less rigidity even if they were satisfied with the gained penile length after any lengthening procedure.

Gontero et al. [15] and Nikoobakht et al. [16] reported penile girth was not changed before

and after application of penile traction device. Although penile traction therapy could not affect girth enhancement theoretically, a present demonstrated increased girth with penile elongation together by using penile traction device [17]. Girth enhancement in this only study was suggested by 0.6–1 cm/month, but the authors did not elucidate clearly what was the mechanism of increased girth by penile lengthening device. For that reason, the authors suggested that penile traction therapy was not appropriate for the patients requesting exclusively an increase in the girth and length of their penis at the same time.

Since vacuum erection device could stretch tunica albuginea longitudinally and circumferentially, vacuum erection device may result in girth enhancement theoretically. But a research using vacuum erection device did not show girth enhancing effect [19].

Erectile Function by Penile Traction Therapy

A study [14] showed that International Index of Erectile Function (IIEF) increased 6 months after penile traction therapy with FastSize Penile Extender (FastSize LLC, CA, USA). Baseline score of IIEF increased from 19.9 ± 8.77 to 27.1 ± 1.40 6 months after device application. Even men with severe erectile dysfunction reached normal score in IIEF, but men having normal IIEF did not decrease to subnormal. Penile traction therapy cannot affect on erectile function theoretically. The authors suggested that it might be due to decreased performance anxiety resulted from restoration of their self-esteem by new penile morphology in men with psychogenic erectile dysfunction. However other researches using penile traction devices did not mention about changes in sexual functions.

Lengthening Efficacy of Vacuum Erection Device

All penile traction devices stretch mechanically the tunica albuginea of the penis externally from penile skin, whereas vacuum erection devices stretch the tunica albuginea internally from distension of corpus cavernosum. An article demonstrated that application of vacuum erection device for 30 min per day for 4–6 months did not show effective penile lengthening [19]. The reason might be difference in application duration. While penile traction devices were usually applied for at least 2–8 h per day, vacuum erection device was only for 30 min per day. Vacuum erection device is not recommended for over 30 min because of ischemic damage of the distal corpus cavernosum from constriction ring. Penile stretching below 2 h per day was showed to fail to gain additional penile length. Therefore, although internal stretching using vacuum erection device could lengthen the penis theoretically, it was thought that vacuum erection device could not demonstrate favorable outcome due to mechanical and physiological limitations of it.

Applications of Penile Traction Therapy

Possible indications which can be applied for penile augmentation or elongation surgery were contradictory or very negative by academic societies because of unexpected serious harms, even positive outcome. The Asia Pacific Society for Sexual Medicine (APSSM) published its guidelines that penile augmentation procedures should be limited to patients who have penile length below two standard deviations from the mean. The Sexual Medicine Society of North America posted a position statement advising that penile lengthening and girth enhancement surgery [20] can only be performed for men with congenital anatomical anomalies of the penis, that the efficacy of penile lengthening and girth enhancement surgery have not been established, and also that adverse outcomes should be disclosed to patients considering penile augmentation or lengthening surgery. Additionally, the American Urological Association [21] released policy statements that the division of the suspensory ligament of the penis for increasing penile length in adults was a procedure which has not been shown to be safe or efficacious.

These guidelines pointed that it should not be done recklessly because penile lengthening surgery could bring unexpected serious adverse

outcome. Therefore, even though application of these medical devices is not invasive surgical procedure, proper candidates should be selected.

Candidates for Penile Traction Therapy

Shortening Penis after Radical Prostatectomy

Penile shortening has been reported after radical prostatectomy in up to 71 % of patients, with a mean decrease of 1.1–4 cm [22–24]. Penile shortening after post-prostatectomy sometimes results in terminal dribbling on the pants on usual voiding. Thus, shortened penis after radical prostatectomy would be a proper candidate for penile traction therapy.

Before Penile Prosthesis Insertion

In case of fibrotic cavernosum with loss of tunica albuginea elasticity due to explanation of infected penile prosthesis, simple penile prosthesis reinsertion do not make the patients satisfy with their penile size. Application of penile traction device before penile prosthesis insertion might increase the size of the cylinder resulting in raising patient satisfaction.

Peyronie's Disease

Correction surgery for Peyronie's disease is associated with penile shortening, which was reported in 7.3–90 % of patients [25–27]. For that reason, men who have complained shortened penis due to correction of Peyronie's disease also would be one of the proper candidates.

Adjuvant Application after Penile Lengthening Surgery

The usual penile lengthening surgery is the division of suspensory ligament, but this procedure can reduce penile length compared to before surgery due to scar contracture developing at the site of severed suspensory ligament, which resulted in shortened penis by entrapment in infrapubic scar. Traction/stretching devices could be used postoperatively for a short duration to prevent the penis being entrapped into the infrapubic scar.

Contraindications

There are no known contraindications yet. But men without active motivation for penile traction therapy would not be expected of good results, because better lengthening effect can be reached by bothersome traction duration as long as possible till 3–6 months and at least 2 h traction per day.

Conclusions

Although surgical phalloplasty gives additional penile length compared to original size and enough satisfaction with gaining length, surgical treatment can result in many and serious complications. If men who are considering lengthening the penis are concerned about postsurgical complications, it will be a challenge to choose a surgical procedure. Therefore less invasive penile traction therapy should be applied firstly than surgical modalities. The most popular medical treatment for penile lengthening is penile traction therapy using traction device. Outcome of penile traction therapy using penile traction device is similar with gaining length from usual surgical procedure, but adverse events are reported nearly none except mild traction pain. Men who complain shortened penis after retropubic surgery or Peyronie's disease, before penile prosthesis reinsertion, and adjuvant therapy after penile lengthening surgery might be proper candidates. All of the men who applied penile traction device did not gain satisfactory penile length, but this may be helpful or one of the good alternatives to the patients who want penile lengthening therapy without serious complication.

Since the research data about safety and efficacy of penile traction therapy, application protocol, and authorized measurement for penile length have been insufficient at the present time,

there is a need for scientific researches on the lengthening outcomes and complication rate of it. In addition, there is also a need to perform prospective randomized clinical trials on large cohorts and to develop validated methods for assessing subjective and objective perception of penile size.

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Part IV

Glans Penis Augmentation

General Principles of GA

21

Du Geon Moon

Introduction

In aspect of the role of the glans penis, besides sexual inferiority, why do so many people want to have big glans penis? What is the role of the glans penis? There is no description about the function of the glans penis in textbooks of andrology, urology, and even anatomy. The penis is the symbol of the male and is a tool for both voiding and sexual intercourse. As a tool for voiding, the essential role of the glans penis can be easily understood based on the purpose of hypospadias repair. The glans penis maintains the straight urinary stream and protects the distal urethra. As a tool for sexual intercourse, the glans penis is a sensory organ for sexual stimuli. Glans erection elongates the underlying elastic rete ridge which exposes more underlying sensory receptors. As a tool for intercourse, the glans penis has a unique function based on its conical shape. The conical glans penis is the proper shape for vaginal dilatation and easy intromission of the penis into the vagina. If the glans size is too small compared to a thick shaft, dilatation or intromission is not so easy and effective. The conical shape of the glans penis is aids in aiming and is effective for transfer of axial cavernosal pressure to the distal tip of the penis. During erection, cushion effects of the glans penis prevent both vaginal trauma and injury of the distal penis. For these reasons, the penis cannot do anything without glans! The penis should look aesthetically normal and relevantly large with respect to the penile body and be as tumescent as the body during erection.

What is the importance of glans penis augmentation? Although augmentation phalloplasty is not an established procedure, the demand for penile augmentation continues to increase as the media exposes normal male figures and advertisements create interest in corrective surgery. Current main augmentation phalloplasty procedures are girth enhancement and penile lengthening. There is no argument against the glans penis augmentation (GPA) for hypospadias repair and penile reconstruction for congenital micropenis or secondary micropenis (iatrogenic, infection, trauma). And the current penile girth enhancement (PGE) technique may produce an iatrogenic penile deformity of thick penile body with a relatively small glans penis. Besides some patients' complaints of poor glans tumescence during normal erection [1], a small glans and lack of tumescence are evident after penile prosthesis implantation [2, 3]. But there are possible controversies of GPA for subjective cases of small glans penis such as sexual inferiority, small glans during erection, and premature ejaculation. There is no established procedure of GPA for the improvement of sexual function. Moreover, clinically, most patients who seek for

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penile enlargement ask for both penile elongation and girth enhancement with additional GPA, if possible. So, many doctors and patients look for GPA, but there is no safe and effective standard method for GPA. The reasons for the absence of GPA were poor understanding of glans penis anatomy and consequent preconception of structural infeasibility, lack of adequate material and ideal implants, and technical shortness. For the development of GPA, the technical feasibility of subcutaneous injection of filler into the glans penis, presence of histological potential space in the glans penis, and long-term residence of implants should be demonstrated [4].

Characteristics of Ideal Filler and Injectable Hyaluronic Acid Gel

Injectable soft-tissue substitutes provide an affordable, nonsurgical alternative for correcting contour defects and soft-tissue augmentation. The ideal filling substance for soft-tissue augmentation should be biocompatible, nonantigenic, nonpyrogenic, noninflammatory, nontoxic, easy to use, stable after injection, nonmigratory, long lasting but reabsorbable, natural looking, and not too expensive [5, 6]. From the late 1990s, hyaluronic acid (HA) has been shown to possess many properties that suggest its value in several medical applications, particularly in ophthalmology, orthopedics, and recent soft-tissue augmentation in aesthetic surgery with proven efficacy and safety [7–9]. A ubiquitous component of all mammalian connective tissue, hyaluronic acid (hyaluronan), is a naturally occurring polysaccharide, with the same chemical and molecular composition in all species, in the intercellular matrix of dermal layers of the skin of all species; therefore, it is highly biocompatible to use animal sources in humans without creating foreign body reactions [10–12]. The hyaluronic acid matrix has an enormous ability to bind water (water content greater than 99 %) and form hydrated polymers of high viscosity [13]. It resides in the extracellular space and functions as a space-filling, structure-stabilizing, and cell-protective molecule with uniquely malleable physical properties and superb biocompatibility. With these unique physical properties, hyaluronic acid has proved to be an ideal material for soft-tissue augmentation [14]. The amount of hyaluronic acid in the skin decreases with age, and loss of this substance results in reduced dermal hydration and increased folding [15]. Their present use is for supplementation of joints, wound healing, and corrective surgery of facial deformity and in the Deflux system of urological field [16]. Restylane and Perlane (Q-Med, Uppsala, Sweden) are injectable hyaluronic acid gels and have the same composition of 20 mg/ml of stabilized hyaluronic acid gel. The difference between the products is the size of the gel particles. Hyaluronic acid is a glycosaminoglycan biopolymer composed of alternating residues of the monosaccharides D-glucuronic acid and N-acetyl-D-glucosamine linked in repeating units. The molecular weight of hyaluronic acid in its pure form can be determined. However, hyaluronic acid in its pure form is not stabilized. Injectable hyaluronic acid gel is a hyaluronic acid product chemically modified to increase its longevity in the tissue and to form a gel. It is not relevant to talk about molecular weight, as it cannot be determined for a stabilized gel.

Establishment of Injection Technique and Histological Study

Although the hyaluronic acid has already been used in its native form as an implant for more than 30 years and in millions of individuals without causing adverse reactions in various fields, there was no report of penile augmentation. For the development of GPA using injectable hyaluronic acid gel, the feasibility of subcutaneous injection into the glans penis, the presence of potential space in the glans penis, and long-term residence of implants with sustained volume effects should be demonstrated. The approximate number of gel particles is 100,000/ml in Restylane and 1000/ml in Perlane. For this reason, Q-Med recommends a

30G needle to inject Restylane into the mid- to upper part of the dermis and a 27G needle to inject Perlane into the deep layer of the dermis.

Based on the same principles of wrinkle correction, Moon DG and colleagues [4] demonstrated the feasibility of subcutaneous injection of Restylane into the small glans penis of New Zealand white rabbit via a 30G needle and the presence of potential space in the dermis (Fig. 21.1). They also injected Perlane into the glans penis of a Beagle dog with a 27G needle and noticed no volume loss for 3 and 6 months in all animals (Fig. 21.2) and long-term residence in the lamina propria (Fig. 21.3).

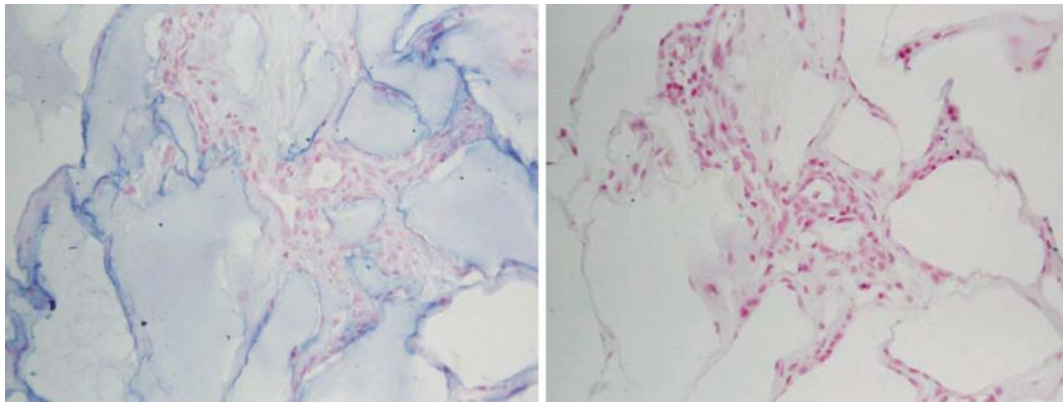

Fig. 21.1 At 3 months after hyaluronic acid gel injection into the dermis of the glans penis in the rabbits. *Left*: Various cavities contain Alcian blue positively stained hyaluronic acid gel: ×200. *Right*: Alcian blue stain after treatment of hyaluronidase reveals the digestion of hyaluronic acid gel in the penis of rabbits: ×200

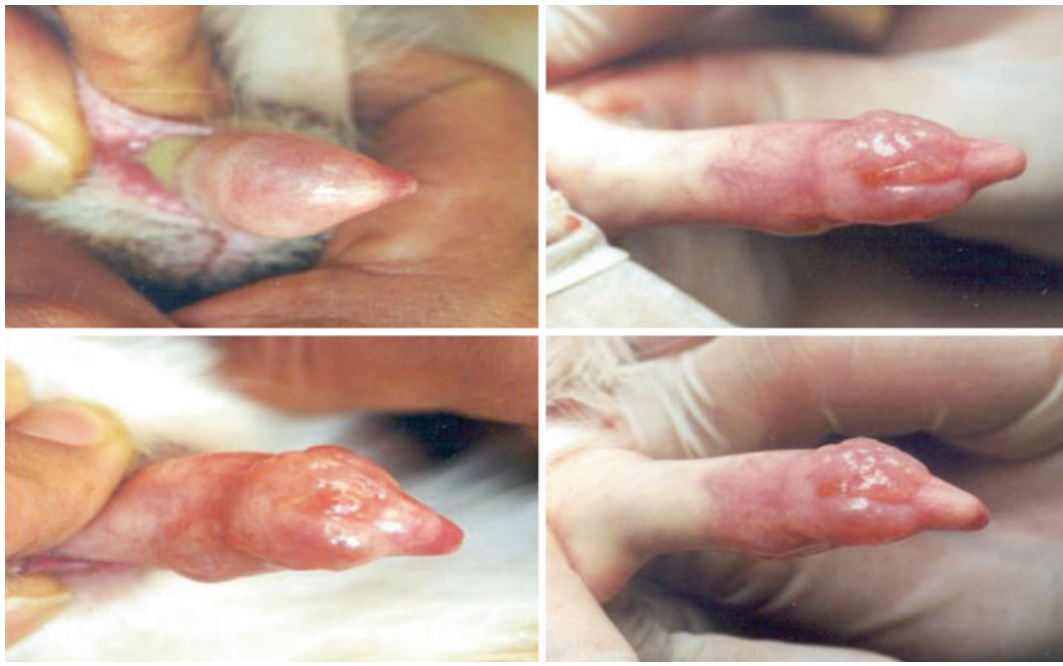

Fig. 21.2 Gross appearance of canine glans penis after injection of hyaluronic acid gel. Implants were well maintained until 6 months. *Left upper*: before injection. *Right upper*: immediately after injection. *Left lower*: 3 months after injection. *Right lower*: 6 months after injection

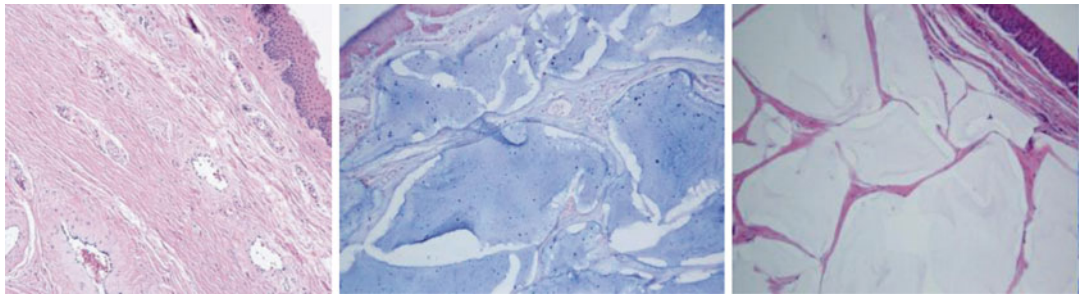

Fig. 21.3 At 6 months after hyaluronic acid gel injection into the dermis of the penis in the Beagle dog. *Left*: Normal control. *Middle*: Implanted basophilic amorphous materials. *Right*: Alcian blue stain after treatment of hyaluronidase reveals the digestion of hyaluronic acid gel, ×200

Feasible Efficacy of GPA for Premature Ejaculation

Current treatment choice for premature ejaculation is medical treatment. The main limitation of medical treatment for premature ejaculation is recurrence after withdrawal of medication. Hypersensitivity of the glans penis as a cause of premature ejaculation is still controversial, but many patients of primary premature ejaculation who respond to local anesthetics have penile hypersensitivity, which provides further implications for an organic basis of premature ejaculation [17]. Dorsal neurectomy is also created to decrease the sensitivity of the glans penis [18]. But dorsal neurectomy is not an established treatment of penile hypersensitivity ejaculation due to the uncertain pathophysiology, invasiveness, and side effects, for example, numbness or paresthesia, pain for neuroma, Peyronie's disease, and even erectile dysfunction. Despite these limitations, dorsal neurectomy is still performed in selective patients who do not respond to conventional treatment of premature ejaculation.

The skin of the human phallus is innervated by the dorsal nerve of the penis (DNP). The main trunk of DNP is composed of two different populations of axons [19]. The first group travels along the dorsal midline and terminates in the glans. The other group of fibers radiates from the main trunk over the lateral and ventral aspects of the penile shaft with branches to the corpus spongiosum and urethra. At 1–2 cm proximal to the corona glandis, the DNP dorsal trunk is divided into two to three nerve bundles. The DNP and its branches along the shaft run just beneath the skin and fascia; the main branches within the glans are 3–6 mm from the epithelial surface. Halata and Munger [20] studied the sensitivity of the human glans penis. The human glans penis is covered by stratified squamous epithelium and a dense layer of connective tissue equivalent to the dermis of typical skin. The papillary dermis blends into and is continuous with the dense connective tissue forming the tunica albuginea of the corpus spongiosum of the glans penis. The most numerous nerve terminals are free nerve endings present in almost every dermal papilla and scattered throughout the deeper dermis. Genital bulbs are present throughout the glans but are most numerous in the corona and near the frenulum. Moon DG et al. postulated theoretical efficacy of GPA in PE. Major contributing factors of sensory characteristics in the glans penis are distribution of dorsal nerve, number of receptor, threshold of receptor, and accessibility of stimuli to the receptor. Considering the studies of Yang [19] and Halata [20], injectable implants can be successfully injected into the dermis of the glans penis just above the nerve terminal. Hence, the creation of barrier by bulking agent that inhibits the tactic stimuli to reach the receptor may be effective in premature ejaculation by decreasing the sensitivity of the glans penis. Moreover, GPA is less harmful than invasive dorsal neurectomy.

Conclusion

Glans penis augmentation has received much less interest from experts despite the presence of a subset of patients who could be dissatisfied with small glans or poor tumescence of the glans during erection. Recently, GPA using injectable filler or implantation of graft or filler has been developed. Among the various options of penile augmentation, surgery is the only proven scientific method in spite of controversy.

Currently, GPA using injectable HA gel is not recommended in the ISSM guidelines due to possible sensory loss. In the 5-year long-term follow-up of glans penis augmentation by subcutaneous injection of HA gel, the residual volume of implants decreased by 15 % of maximal glandular circumference but was still effective for the hypersensitivity of the glans penis in premature ejaculation patients. For the efficacy in premature ejaculation, selection of proper patient is most important, and GPA is not harmful for erectile function and less invasive and irreversible compared to dorsal neurectomy. To refine the procedure, more interest and proper studies are requested for the establishment of a procedure. GPA is not an evil trick but a necessary procedure for relevant indications.

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Glans Penis Augmentation by Filler

22

Du Geon Moon and Tae Il Kwak

Introduction

Unlike meatal advancement with glanuloplasty or glans approximation for hypospadias repair, recently minimal invasive procedures of glans penis augmentation (GPA) have been developed for sexual inferiority. Direct GPA has been recently developed. Compared to direct enhancement of the dermal layer of the glans penis by superficial injection of filler [1–3], indirect GPA in which implantation of dermofat graft or collagen scaffold between the glans and corporal tip [4] can make general enlargement and elevation of the glans penis. In 2003, Moon DG and colleagues firstly reported novel GPA method using injectable hyaluronic acid gel with the same principle of wrinkle correction [5] and reported three consecutive human studies of GPA for volume effects, premature ejaculation, and long-term follow-up results of 5 years in 2008 [1, 4, 5]. After the development of GPA using injectable HA gel, various kinds of fillers have been used. In 2003, Perovic et al. [2] reported his results of GPA by submucosal injection of hydrogel in nine patients of glans deformity. Shaeer also used polyacrylamide gel injection for enhancing glans size in two patients following implantation of a penile prosthesis with satisfactory results, although short lived, requiring reinjection [3]. Abdallah et al. reported modified GPA using injectable hyaluronic acid gel for premature ejaculation patients by multiple puncture technique for easy and large amount injection [6].

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Direct Glans Penis Augmentation

Human Glans Penis Injection Technique

For human glans penis injection, local anesthesia 30 min after topical application of anesthetic cream Emla (lidocaine 25 mg, prilocaine 25 mg, AstraZeneca) is tolerable for most patients, but a few present penile pains and require local injection of anesthetics. For the development of easy and successful injection, linear threading technique was introduced at the beginning but needs too much puncture (Fig. 22.1). Thereafter, hyaluronic acid gel was injected by the fan technique (Fig. 22.2). Less number of needle puncture is required because too much puncture can cause mucosal tearing, bleeding, and leakage through the needle site. In both techniques, injection needle was indwelled subcutaneously at proximal one-third from tip of the glans to coronal sulcus. In human glans penis, it is not so difficult to inject hyaluronic acid into the dermis of the glans penis. Beside of the elastic nature of glans penis, most

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Fig. 22.1 Linear threading technique

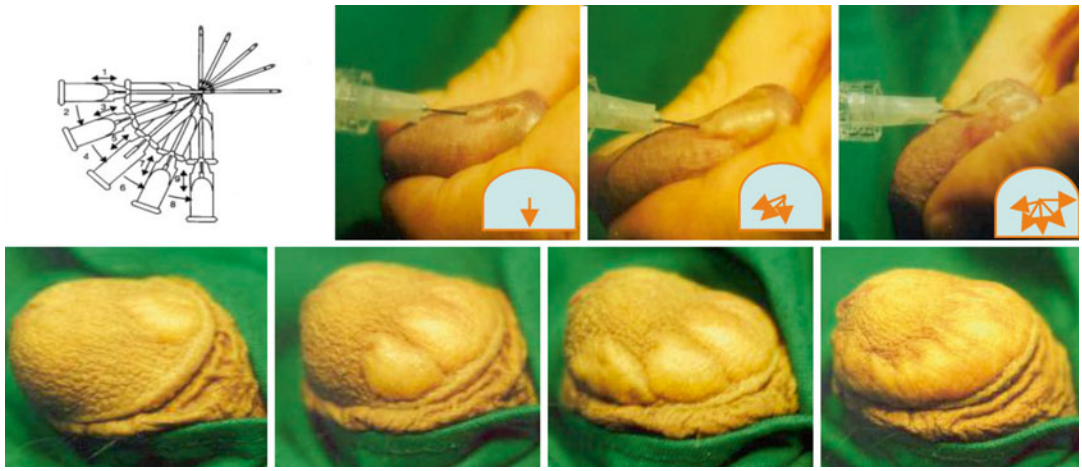

Fig. 22.2 Fan technique

surgeons are already familiar with this technique, which is frequently used to make subcutaneous bulla for skin test of hypersensitivity and for easy dissection of subcutaneous tissues. To avoid over injection, the relevant volume of Perlane (hyaluronic acid gel, Q-med, Uppsala, Sweden) is 2 ml. After initial injection of Perlane, supplemental injection of Restylane (hyaluronic acid gel, Q-med, Uppsala, Sweden) via 30G needle is useful to correct the uneven undulation of glandular surface. But, the injection technique is not so easy for the beginner for even distribution of the gel through the whole glans penis. Unlike facial skin, the glans has multiple tiny folds originated from the underlying rete ridge, and the augmented surface is inevitably uneven and looks unnatural. But the tiny folds and inevitable minor surface undulation disappear during erection which originate from the undulation of underlying rete ridge.

Although not described by Moon et al., it is very difficult to inject the ventral side just close to the frenulum and whole marginal area along the coronal sulcus [5]. In 2012, AbdAllah H et al. developed multiple puncture techniques and compared it with fan technique in their pilot study [6]. They used multiple points of entry starting from proximal one-third of the glans along the coronal sulcus together with the frenulum and injected only 0.25 ml at each point. They reported that their injection technique has the advantage over the fan technique in that it allows more uniform distribution of the injected material with less pain, because the size of the bulla

created is smaller than that created using the fan technique. To avoid initial too much volume injection and consequent discoloration or pressure necrosis, initial injection of 2 ml of injectable hyaluronic acid gel (Perlane, Q-med, Uppsala, Sweden) via a 27G needle and supplemental injection of Restylane via 30G needle at 2 weeks after initial injection was recommended by Moon et al.

Effects of GPA for Volume Effects

To estimate the volume effects of GPA by injectable hyaluronic acid gel or other kinds of fillers, long-term residual volume should be assessed. There is no established objective method to estimate the residual volume of implants and long-term results in fields of cosmetic surface augmentation. Even the most sensitive imaging study cannot measure the accurate remnant volume because of the relative small injected volume, uneven distribution, and changes of nature of implants through long tissue interaction. For these limitations, Kim JJ et al. estimated the changes of glandular diameter, patient's subjective visual estimation of glandular size, and patient's satisfaction for efficacy and early and late complications [1]. Changes in glandular diameter were measured by tapeline to identify the net increase in the maximal glandular circumference after augmentation of the glans penis. Patient's subjective visual estimation of glandular size was requested to assess the residual volume of hyaluronic acid gel. The patients estimated the visual analogue scale from grade (Gr) 0 to Gr 4: Gr 0, no residual volume; Gr 1, less than 25 % of initial volume; Gr 2, less than 50 %; Gr 3, less than 75 %; and Gr 4, more than 75 % or nearly same as initial volume. Patient's satisfaction was also evaluated from Gr 0 to Gr 4: Gr 0, very dissatisfied; Gr 1, moderately dissatisfied; Gr 2, about equally satisfied and dissatisfied, Gr 3; moderately satisfied; and Gr 4, very satisfied. Any adverse reactions were also evaluated. In 100 patients of subjective small glans penis, the maximal glandular circumference was significantly increased compared to basal circumference, and net increase of maximal glandular circumference was 14.9 ± 30.80 mm at 1 year after injection. In patient's visual estimation, 38 and 57 % of the patients estimated the residual volume as more than 50 and 75 % of initial volume and 77 % of patients satisfied with their 1 year results. In 87 patients of small glans after PGE with dermofat graft, net increase of maximal glandular circumference was 14.78 ± 0.89 mm. In visual estimation, 29.9 and 70.1 % of the patients estimated residual volume as more than 50 and 75 % of the initial volume, and 69 % of patients were satisfied. There was no abnormal reaction in area feeling, texture, and color. In most cases, initial discoloration by glandular swelling recovered to normal within 2 weeks. Postoperative consistency of the glans penis was natural without deformity and maintained through 1 year. There were no signs of inflammation and no serious adverse reactions in all cases.

For long-term residual volume of implants and efficacy, Kwak TI et al. followed a total of 38 patients for 5 years [7]. Compared to 6 months, net increase of maximal glandular circumference was 14.10 ± 0.65 mm but decreased by 15 % at 5 years. Mean grade of patient's visual estimation was not significantly different between 6 months and 5 years. And there was no significant difference in the percentage of patient's satisfaction (Grs 3 and 4) between 6-month and 5-year follow-up. But, the mean grade of the patient's visual estimation was unchanged after 5 years compared with postoperative 6 months (Gr 3.60 vs 3.56). It means that the patients might not recognize the volume loss with the naked eye. A major advantage of HA gel over nonpermanent fillers, such as fat and collagen, is the increased tissue longevity. The slow digestion of this gel shows that stabilization of the material through cross-linkage is able to increase its longevity several 100-folds compared to the natural polymer, without decreased biocompatibility. The implant has a property of degradation but has a characteristic of isovolemic degradation. The isovolemic degradation keeps the gel always in balance with water in the tissue, and this increased capacity to bind water of a less concentrated hyaluronan network allows maintaining the correction even in

low concentrations of the materials. So, the gross appearance of the glans penis did not show any deformity at 5 years after augmentation in all patients. Despite the isovolemic degradation of HA supported by Q-med, ultimate time-dependent reabsorption can induce deformity which requires additional injection, but another advantage of HA gel is easy supplementation by reinjection in cases of long-term volume loss. Although manufacturers and different publications claim that the fillers are nontoxic and non-immunogenic or that complications are very uncommon [8], unwanted side effects occur with all compounds used [9–11]. In the early reports of HA injection for cosmetic purposes, no significant signs of bio-incompatibility were reported [12, 13]. Recent evidence may show that major, local and/or systemic, and immediate or delayed adverse effects may appear in relation with its use [14]. But in this study, there was no serious adverse reaction after 5 years follow-up like delayed and recurrent chronic inflammatory and granulomatous reactions.

Efficacy of GPA for Premature Ejaculation

Kwak TI et al. compared the efficacy of GPA with dorsal neurectomy in a total of 139 patients of primary premature ejaculation [7]. GPA with injectable hyaluronic acid gel was performed as they developed. The extent of nerve fibers, including in dorsal neurectomy, is important in postoperative sensory of the glans penis. To avoid excessive sensory loss, dorsal branch at one side and ventral and lateral branches on the other side were excised in this study. At 6 months after each procedure, volume effect same as in GPA study, ejaculatory latency, vibratory threshold of the glans penis using a bio-thesiometer (Bio-Medical Instrument Co., USA), patient's satisfaction, and partner's satisfaction were evaluated. In patients of GPA, postoperative ejaculatory latency and vibratory threshold were significantly increased, and 75 % of patients were satisfied. In 10 of 74 patients with dorsal neurectomy, numbness (6), paresthesia (4), pain from neuroma (3), and Peyronie's disease (1) occurred, while no patients presented sensory loss in 65 patients of GPA. Abdallah et al. also reported the increased IELT after 1 month of GPA using injectable HA gel and decrease of IELT after 3 months but still significantly higher than baseline [6]. From 2010, ISSM guidelines for Diagnosis and Treatment of Premature Ejaculation classified the role of surgery, selective dorsal nerve neurectomy, or HA gel GPA as Level 4 of no evidence [15]. They do not recommend surgery which may be associated with permanent loss of sexual dysfunction based on this study. But it is an evident mistake of ISSM guideline committee in interpretation of study results. In dorsal neurectomy patients, there was significant decrease of sensory measured by ET and VT, but no permanent complication in patients of GPA alone. Compared to dorsal neurectomy, GPA has additional benefit in premature ejaculation without significant side effects or sexual dysfunction due to sensory loss.

Although the increase of IELT after GPA and efficacy in selective patients of premature ejaculation have been reported, major limitations are invasiveness, side effects, and possibility of further sensory loss in longer period. For long-term efficacy and side effect of GPA in PE, Moon et al. followed a total of 38 patients for 5 years. Compared to 6 months, IELT and VT were significantly decreased at 5 years but still remained as increased compared to baseline. And percentage of patient's satisfaction at 5 years was same high as in 76 % of patients at 6 months. Despite the bias in follow-up patients and non-available patients, patients who were satisfied at 6 months mostly remained satisfied until 5 years.

Despite poor understanding of the pathophysiology in premature ejaculation, the effects of GPA using filler in PE might be the results of reduced sensory of the glans penis by formation of barrier for stimuli to access the receptor and increased self-esteem. To increase the efficacy of glans penis augmentation by filler for premature ejaculation, proper patient selection is most important. As demonstrated in this study, the

initial satisfaction rate of 6 month was maintained until 5 years despite significant decrease of IELT and VT. The increased self-esteem and self-confidence from enlarged glans may act positively. It means proper patients selection, and well-done procedure can make patients satisfied.

Complications of Fillers for GPA

After the development of GPA using injectable HA gel, various kinds of fillers have been used. In 2003, Perovic et al. [2] reported his results of GPA by submucosal injection of hydrogel in nine patients of glans deformity. He reported that hydrogel was safe and effective in 8 of 9 cases for 12–26 months follow-up, but he recommended simple aspiration for excessive hydrogel, if necessary. Shaeer [3] also used polyacrylamide gel injection for enhancing glans size in two patients following implantation of a penile prosthesis with satisfactory results, although short lived, requiring reinjection. The advantage of hydrogel is cheaper in price. But later, polyacrylamide hydrogel has been proved as bad for soft tissue augmentation. Hydrogel was the former filler of substitution bag for mammoplasty and used for the correction of facial deformity. In 2003 and 2004, various complications of hydrogel such as diffuse paranasal swelling and signs of cellulitis from the granulomatous inflammatory response were reported, and the warning was that hydrogel injection does not adapt to facial plasty [16–18].

Despite the proven safety in both aspects of unique characteristics of hyaluronic acid and clinical experiences, granulomatous foreign body reaction by protein contaminants and rare ischemic necrosis can be developed by too superficial and too much volume injection or intravascular injection which cause immediate postinjection discoloration. Brody HJ [19] and Hirsh RJ [20, 21] reported the successful management of an unusual presentation of impending necrosis following a hyaluronic acid injection embolus and a proposed algorithm for management with hyaluronidase. In case of immediate postinjection discoloration, stopping injection, applying gentle massage, immediate application of heat, and local nitroglycerine paste maybe effective. If not improved, intradermal injection of 75 U hyaluronidase (VitraseTM, Ista Pharmaceuticals, Irvine, CA) or 0.5 cc of 150U hyaluronidase (Lee Pharmacy, Inc., Fort Smith, AZ; 50 U/mL) will be effective in disappearance of 90 % lumpiness in 24 h and remainder for several more days. To avoid possible immediate ischemic necrosis, use of safe, ideal filler and supplementation at postoperative 2 weeks instead of initial over injection and injection of hyaluronidase in case of HA gel are good alternatives. Although not reported, several complicated patients were referred (Figs. 22.3, 22.4, and 22.5). The reason for the local complications after filler injection is use of inadequate filler such as unknown nature or poor purity of filler and wrong injection technique such as too much volume injected too superficially and misplacement and local infection.

BellaGen is a suspension of modified SureDerm, cellular dermal fragment 500–1000 μm, which composed of a BellaGen 1 cc/5 ml syringe and 1.5 cc lidocaine + 0.3 cc gentamicin/ 3 ml syringe. In case of discoloration after overinjection, it cannot be aspirated, or hyaluronidase cannot digest the cellular fragment. Nowadays, various kinds of fillers are developed. As illustrated in Fig. 22.6, some physicians favor fat injection, but surgical removal is very difficult even in successful case if unsatisfactory patients (Fig. 22.6).

Indirect GPA

After development of GPA using injectable HA gel, Shaeer O reported glans augmentation by grafting which he named as *Shaeer's glans augmentation* [22]. He also stated the necessity of GPA in patients lacking glans tumescence in penile prosthesis implantation or during natural erection and small glans after augmented shaft. *Shaeer's glans augmentation* is insertion of dermofat graft from the groin into the periurethral plane which was developed by dissection of glans

Fig. 22.3 Suspected use of polyacrylamide

Fig. 22.4 Suspected use of Rofilan®, Rofil, Netherland

flap via two ventral incisions along the ventral aspect of the coronal sulcus (Fig. 22.7).

In this pilot study of ten patients, maximum circumference of the glans increased by 16.6 %, declining to 14.2 % at 10–12 months, which is a 2.3 % decline. Self-reported impression of the augmented volume was high and well maintained over the follow-up period. Glans sensation, engorgement, erectile function, and ejaculatory control were preserved. This pilot study on glans augmentation by grafting reports promising results with retention of the added volume at 1-year follow-up, preservation sensitivity and engorgement, and no adverse effects on erectile function or ejaculatory control. Despite good results, major limitations of this study are invasiveness of dermofat graft from the groin and lack of long-term results. Another similar method of GPA was reported in Korea but is unpublished.

A group of Korean andrologists developed this method. Compared to direct enhancement of

Fig. 22.5 Serial changes of pressure necrosis after over injection of BellaGen (Modified SureDerm®, Hans Biomed Corp, Korea)

Fig. 22.6 Subcutaneous injection of autologous fat

dermal layer of the glans penis in direct GPA by superficial injection of HA gel, indirect GPA, implantation of collagen scaffold, Lyoplant, between the glans and corporal tip, can make general enlargement and elevation of the glans penis as illustrated in Fig. 22.8. As reported by Perovic et al. [23], a potential space between the corpus spongiosum of the glans penis and the distal tip of corpus cavernosum can be developed by blunt dissection via incision at coronal sulcus. During preservation of the dorsal neurovascular bundle, the prepared commercial dermal strip, silastic bar, or dermis (autologous, AlloDerm, Lyoplant) can be implanted. Simple closure and usual wound care are enough. At the beginning, they also used dermofat graft and changed to Lyoplant because of invasiveness. Lyoplant implantation showed good results, but reabsorption was a problem. This novel method looks very simple and easy, but the limitations are invasiveness, no proven efficacy, and no more reports (Fig. 22.8).

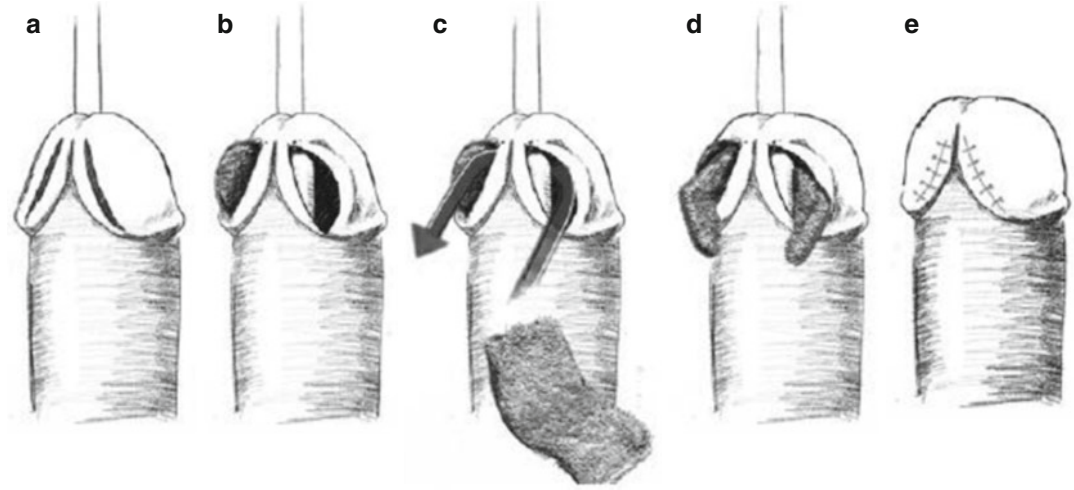

Fig. 22.7 Surgical steps. (**a**) Incision; (**b**) dissecting glans flaps; (**c**) the periurethral plane; (**d**) graft insetting; (**e**) incision closure

Fig. 22.8 Preparation and procedures of indirect GPA, Lyoplant insertion

Conclusion

Despite demanding injection technique and inevitable uneven undulation of glandular surface, GPA using injectable HA gel is a novel, necessary achievement and very effective and safe procedure as soft tissue enhancement. For long-term residence of implants for several years, timed supplementation is good as in facial plasty. GPA using HA gel should be differentiated from GPA using other kinds of fillers such as fragments of scaffold and acelluar or cellular derivatives. For complications such

as mucosal necrosis of the glans penis, most cases occurred from the use of non-HA gel or unpurified form and misknowledge of the management protocol for the immediate side effects.

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Part V

Regenerative and Reconstructive Techniques

Regenerative Medicine Approaches to Repair Penile Structure and Function

23

J. Koudy Williams, Ashley Jane Dean, and James J. Yoo

Introduction

Penile repair and reconstruction are needed for a variety of diseases and injuries, including Peyronie's disease, hypospadias, epispadias, urethral stricture, penis fractures, burns, bites, infections, penetrating injuries, and blunt force trauma [1–4]. Damage to penile tissue often leads to loss of sexual function that can profoundly affect quality of life. When the penile defect or injury is sufficiently large, cannot be managed conservatively, and involves the urethra and rupture of the tunica albuginea and corpora cavernosum, various surgical procedures, such as penile prostheses and autograft implantation, are required. While cosmetic appearance may be improved with these procedures, restoration of spontaneous and natural erectile function is usually not achieved. This is often due to critical defect of the corpora cavernosa, which is responsible for erectile function.

Current penile reconstructive techniques are limited by tissue availability and compatibility. Physicians and scientists have begun to explore tissue engineering and regenerative medicine strategies for repair and reconstruction of the genitourinary tract. Tissue engineering allows the development of biological substitutes which could restore both structure and function. Tissue engineering efforts designed to treat or replace most organs are currently being undertaken. Most of these efforts have occurred within the past decade. However, before these engineering techniques can be applied in patients, further studies are needed to ensure the safety and efficacy of these new materials and methods. Recent progress suggests that engineered urologic tissues and cell therapy may soon have clinical applicability.

Both synthetic and natural matrices have been used to bioengineer the urethra [5–10] and form the scaffold of the penis [11]. Alternatively, scaffolds can be seeded with cells, and the resulting construct can be implanted into the patient to restore the structure and function. Recently, new methods of cell culture have been developed which allow large numbers of autologous cells to be grown ex vivo from a small sample of a patient's own tissue. These cells can then be combined with an appropriate scaffold material. This process is able to generate the large amounts of tissue required for genitourinary reconstruction

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without the donor site morbidity associated with grafting procedures. In addition, the engineered tissue would be biocompatible, and the risk of rejection would be eliminated. Bioengineered tissues have traditionally involved two components: (1) biomaterials and (2) cells. There are new emerging approaches that may obviate the need for both of these components and they will be discussed. The basic approach to engineering penile tissues will be discussed.

Biomaterials

Biomaterials can provide a three-dimensional space for support and for the cells to form into new tissues with appropriate structure and function. Biomaterials also serve as hosts for the delivery of cells and appropriate bioactive factors (e.g., cell adhesion peptides and growth factors) that attract native cells to desired sites in the body [12]. In that sense, they are necessary to provide the microenvironmental niche for the cells. Generally, three classes of biomaterials have been used for engineering tissues and organs: (1) naturally derived materials – such as collagen; (2) acellular tissue matrices – such as bladder submucosa and small intestinal submucosa; and (3) synthetic polymers – such as polyglycolic acid (PGA), polylactic acid (PLA), and poly(lactic-co-glycolic acid) (PLGA). Naturally derived materials and acellular tissue matrices have the potential advantage of biologic recognition and preexisting three-dimensional structure, but synthetic polymers can be produced reproducibly on a large scale with controlled properties of strength, degradation rate, and microstructure and components.

Of the natural materials, collagen has been the most widely used and can be readily purified from both animal and human tissues [13]. Collagen has long been known to exhibit minimal inflammatory and antigenic responses [14], and it has been approved by the US Food and Drug Administration [15]. This material can be processed into a wide variety of structures such as sponges, fibers, and films [15–17] of varying strengths and conformations, thus making it a desirable matrix for penile reconstruction.

One such application is using tissue matrices containing collagen and elastin prepared by mechanical and chemical manipulation of a segment of bladder tissue [18–21]. The matrices slowly degrade after implantation and are replaced and remodeled by native extracellular matrix synthesized and secreted by transplanted or ingrowing native cells. An advantage is that the structures of the proteins (e.g., collagen and elastin) in acellular matrices are well conserved and normally arranged, and the mechanical properties of the acellular matrices are more similar to native tissues than synthetic matrix or submucosa [18].

Polyesters, including PGA, PLA, and PLGA, are often used in applications of regenerative medicine. The degradation products of PGA, PLA, and PLGA are nontoxic and eventually eliminated from the body [22, 23]. Because these polymers are thermoplastics, they can easily be formed into a three-dimensional scaffold with a desired microstructure, gross shape, and dimension by various techniques – including molding, extrusion [24], solvent casting [25], phase separation techniques, and gas-foaming techniques [26]. More recently, techniques such as electrospinning have been used to quickly create highly porous scaffolds in various conformations [27–30]. A drawback of the synthetic polymers is lack of biologic recognition, biomechanical strength, and their suturing properties.

The scaffolds for corporal tissue engineering have included a variety of synthetic and naturally derived materials [31–33]; biodegradable synthetic materials, such as poly-lactic and glycolic acid polymers; natural material such as collagen and fibronectin [34, 35]; and decellularized native tissue [36] have all been used.

A new generation of biomaterials has been bioengineered to better recapitulate the microenvironment of native biomaterial and enhance their receptivity to seeded cells and attraction of native cells [37]. These biomaterials incorporate nanoscience, chemical and surface alterations, and fabrication into structures that optimize the attraction and differentiation of cells. Each biomaterial will require extensive testing for safety and efficacy and approval by the FDA, but are

equally likely to represent the future of penile and other tissue replacement and repair.

Cells

The other component of bioengineered tissues is seeded cells. Various cell sources are used, with autologous cells providing the least rejection risk. For the most part, embryonic stem cells, although having the capability to differentiate into most any cell type in the body, are not used a great deal because of supply and ethical concerns [22]. They also can form teratomas and evoke an immune response. An alternate source of stem cells is the amniotic fluid and placenta. Amniotic fluid and the placenta contain partially differentiated multiple cell types derived from the developing fetus. Isolated stem-cell populations from these sources have been shown to express embryonic and adult stem-cell markers [38]. Unlike human embryonic stem cells, the amniotic fluid stem cells (AFS) do not form tumors in vivo. Lines maintained for over 250 population doublings retained long telomeres and a normal karyotype. AFS cells are broadly multipotent and have been shown to differentiate into all three germ layer cells.

Another option for cell source is to reprogram the cells. Reprogramming of cells offers the opportunity to use autologous fully differentiated cells that can be induced to form many different cell types and all three germ layers [39]. They offer a potentially significant source of autologous cells, and methods are now being devised to reprogram them in ways that do not require aggressive virus transduction.

One of the unexpected sequelae of embryonic cell limitations was the discovery and characterization of adult stem progenitor cell populations. While not having the plasticity of embryonic cells, they can be obtained from the specific organ to be regenerated, expanded, and used in the same patient without rejection in an autologous manner [20, 38–53]. Specific to this chapter, bladder, ureter, and renal pelvis cells can be harvested, cultured, and expanded for urologic applications [46, 48, 53–61].

Of course, a primary component of any penile replacement would be the source of cells. It is essential that these cells interact with each other in a coordinated manner to control erection. While the most common types of cells found in penile tissues (muscle, fibroblasts, endothelial cells) are found in various tissues in the body, it is uncertain whether cells obtained from non-erectile tissues would display similar characteristics as the cells found in the corporal tissue. Studies have used various tissue sources including cavernosal and human tissue [36, 62, 63]. Regardless of the cell sources, it is important that these cells function correctly.

One of the technical difficulties in any tissue for implantation is the efficient delivery of cells to target locations within the scaffold and is especially challenging in penile tissue. To maximize the delivery of cells into corporal scaffolds, a dynamic seeding method has been used effectively [64]. Recent advances in technology development have allowed for use of inkjet printing techniques to precisely deliver different cell types to their designated target locations within a scaffold [65]. Utilization of these technological modalities may allow for building improved tissues for functional restoration.

Urethral Repair

Acellular scaffolds have been used in animal models to facilitate the regeneration of urethral tissue [66–68]. Biodegradable scaffolds such as polyglactin fiber mesh coated with polyhydroxybutyric acid have been used to reconstruct urethras in dogs [34]. In this study, canine urethra was excised and replaced with this material. At 8–12 weeks after implantation, the urothelium and surrounding smooth muscle had regenerated. Furthermore, polyglactin fiber mesh with incorporated hyaluronan benzyl ester has been used in a rabbit model. Importantly, degradation of the biomaterial was apparent 3 days after implantation, and epithelialization and collagen remodeling of the surrounding structures were seen within 4 weeks [69].

Native tissue sheets have also been used as scaffolds. These include tubularized peritoneum, which has resulted in good epithelialization of the neourethra of rabbits [70]. Initial studies using small bowel submucosa have also shown urethral regeneration supported by vascularization and smooth muscle formation [35]. More recent studies of a commercially available small bowel submucosal patch did not show any improvement in regeneration of the urethra versus native healing in a rabbit model of urethral injury [43].

In a rabbit model, segments of urethra have been resected and replaced with bladder-derived collagen matrix in an onlay fashion, and the animals were able to successfully void through the reconstructed urethra [21]. This model has also been applied clinically in patients with hypospadias who had undergone previous repair [43].

Similar collagen scaffolds have also been used to repair urethral strictures [33]. Scaffolds were prepared in a similar fashion as above and sutured to the urethra. After mean follow-up of 37 months, 24 of the 28 patients had a successful outcome with no decrease in urethral caliber. These studies demonstrated that collagen scaffolds appeared to be beneficial for patients with abnormal urethral conditions. In follow-up with these patients 3 years later, they continued to do well with no clinical changes from the initial postoperative period [71].

Despite these successes, it has been shown that tubularized urethral repairs with acellular scaffolds are not feasible because native cells do not fully incorporate into the circumferential scaffold for defects greater than 0.5 cm [72]. In these situations, cell-seeded collagen scaffolds are preferable [73]. One of the initial limitations to using cell-based therapy for genitourinary applications had been the ability to grow urothelial cells in large quantities. More recently, a number of techniques have been developed which allow for the large-scale expansion of these cells without the need for enzymatic digestion or serum [46, 61, 74, 75]. With the development of these techniques, it is now possible to collect autologous urothelial cells from patients, expand them in culture, and return them to the host in quantities necessary for reconstructive procedures.

In a clinical study, efficacy of tubularized urethral grafts was evaluated in five boys (10–14 years of age) with posterior urethral defect whose ages ranged from 10 to 14 years old [76]. Bladder biopsy samples from each patient were used to isolate autologous smooth muscle and urothelial cells. Biodegradable mesh made of polyglycolic acid (PGA) was used as the scaffold and the implants ranged in size 4–6 cm (median 5 cm). Epithelial cells were seeded onto the luminal surface and muscle cells onto the outer surface of the tubular scaffolds. Cell-seeded scaffolds were anastomosed at the site of defect. Patients were followed up for a median of 71 months. Postoperative cystourethroscopy confirmed the radiographic findings of a patent urethra in all patients. Uroflowmetry showed adequate flow rates. Importantly, histologic evaluation of engineered urethra showed normal anatomy with epithelial and smooth muscle layers 3 months after surgery.

Erectile Dysfunction

Erectile dysfunction is one of the most common penile problems reported to physicians and is most commonly treated with medicinal and surgical methods [77, 78]. Penile implants for erectile dysfunction are somewhat successful but are also associated with complications including infection, erosion, and mechanical malfunction [79]. Regenerative medicine has emerged as an alternative approach for erectile dysfunction. One study evaluated the feasibility of creating natural penile prostheses composed of cartilage [80]. Chondrocytes were seeded onto preformed cylindrical polyglycolic acid (PGA) polymer rods and then implanted in athymic mice. Unseeded scaffolds were used as the control. Seeded cartilage formed from the seeded, but not the unseeded scaffolds. A subsequent study was performed to determine the feasibility of engineering human cartilage rods for potential use as penile prostheses [81]. Chondrocytes from the human ear were seeded on rod-shaped biodegradable polymer scaffolds and implanted into athymic rats. After 2 months, chondrocytes

formed flexible cartilaginous rods, similar in size to the initial implants, and with mature chondrocytes. The mechanical properties of these cartilaginous rods were comparable to those of commercially available silicone prostheses. In a subsequent study using autologous cartilage cells seeded on PGA and implanted into the corporal space of ten rabbits [82], cartilage structures were formed within the corpora, with polymer degradation by 2 months.

Corporal Repairs

Repair of the corpora is complex and must include considerations for its anatomy. The penis is composed of three separate cylinders. Two paired cylinders called the corpora cavernosa make up the majority of the penis and are the primary structures involved in erectile function [1, 2]. The corpora cavernosa consists of a network of large venous sinuses separated by dense connective tissue called trabeculae. During erection, blood enters the corpora from the cavernosal artery into helicine arteries and finally into the sinuses. These sinuses are later drained by smaller veins emptying into the dorsal vein. The third cylinder is called the corpus spongiosum, and it houses the urethra. Each of the three corpora is covered by a thick fibrous surrounding layer called the tunica albuginea. All three of these cylinders are covered by a thick membrane known as Buck's fascia. Finally, Collie's fascia, which is continuous with the abdominal wall, covers the entire structure [11].

Extensive reconstructive procedures involving the corporal bodies may be needed in patients with congenital malformation, malignancy, or trauma. Due to the shortage of autologous tissues, these surgical procedures are typically staged and often utilize nonpenile tissues as a grafting material. These procedures have a high risk of complication due to infection, donor site morbidity, and graft failure [83, 84]. The creation of alternative materials is a major challenge for phallic reconstruction due to the unique anatomical architecture of the corporal bodies.

The corporal bodies only contain two primary cell types: smooth muscle and endothelium. In initial studies, Kershen et al. [85] looked at the feasibility of using human corporal smooth muscle cells for reconstructive procedures. Implants were retrieved at 7, 14 and 24 days after surgery for analyses. Corporal smooth muscle cell layers were observed along the surface of the polymers at all time points. At the periphery of the implants, early vascular ingrowth was evident by 7 days and polymer degradation by 24 days postimplantation. Smooth muscle phenotype was confirmed immunocytochemically and by Western blot analyses with antibodies specific to alpha-smooth muscle actin. This study provided the first evidence that cultured human corporal smooth muscle cells that, in conjunction with biodegradable polymers, have the potential to create corpus cavernosum tissue in the laboratory.

One of the major considerations of bioengineering tissues is to supply the new tissue with oxygen and nutrients. This is especially important in a highly vascularized structure such as the penis. Park et al. [52] investigated the possibility of developing vascularized human corporal tissue in vivo by combining smooth muscle and endothelial cells. Primary human cavernosal smooth muscle cells and human endothelial cells (ECV 304) were seeded on biodegradable polymers. Forty-two days after implantation, all seeded polymer scaffolds had formed distinct tissue structures and maintained their preimplantation size, while the unseeded had decreased in size. Importantly, the presence of neovascularization in the seeded scaffolds was observed in as little as 5 days postimplantation. Additionally, increased smooth muscle organization and accumulation of endothelium lining the luminal structures were evident 14 days after implantation. A well-organized construct, consisting of muscle and endothelial cells, was noted at 28 and 42 days after implantation.

Studies by Falke et al. replaced short segments of the corporal body by using natural collagen scaffolds and autologous cells [86]. This was accomplished by harvesting donor rabbit corpora and decellularizing them. Human corporal smooth muscle and endothelial cells [87, 88]

were then seeded in a stepwise fashion, and the constructs were implanted into athymic nude mice. Tissues were harvested at sequential time points after implantation and demonstrated the presence of neovascularity in the sinusoidal spaces with increasing organization of smooth muscle and collagen over time. Organ bath studies demonstrated the ability of these harvested tissues to contract. No response was seen in unseeded control specimens. Further studies by this group demonstrated the ability to bioengineer entire pendular penile corporal bodies in a rabbit model [89]. Again, decellularized donor corporal bodies were seeded with autologous smooth muscle and endothelial cells in a stepwise fashion. Rabbits then underwent complete excision of the corporal bodies followed by implantation of seeded scaffolds, unseeded scaffolds, or no construct. The group implanted with seeded scaffolds demonstrated normal intracavernosal pressures within 6 months of surgery. Functional and structural parameters, including cavernosography, cavernosometry, mating behavior, and sperm ejaculation, were observed for 6 months following implantation. The engineered corporal bodies demonstrated intact structural integrity on cavernosography and decreased maximal intracavernosal pressure on cavernosometry compared to nonsurgical controls. Mating activity in the animals with engineered corpora appeared normal by 1 month after implantation. The animals with implanted corpora were placed with female rabbits, and copulation attempts were made within 30 s. Control animals that received acellular matrix alone showed a decrease in mating activity. In addition, the rabbits with implants were able to ejaculate, and the presence of sperm was confirmed in all rabbits with engineered corpora.

To improve the cellular content of these bioengineered corporal bodies, corporal cells were seeded dynamically onto acellular corporal tissue matrices and placed in a mechanical bioreactor for 48 h. These constructs were then implanted into nude mice. Histology demonstrated that dynamically seeded scaffolds lead to biochemically improved corporal tissues [64]. These studies support the hypothesis that smooth muscle and endothelial cells seeded on acellular corporal tissue matrices (dynamically or not) are able to form vascularized, functional corporal structures in vivo. Therefore, formation of corporal structures using the tissue engineering approaches may produce penile implants similar in structure and function to that of the native erectile tissue and may provide additional options in the management of complex penile reconstructive challenges.

Recently, there have been increased reports of using a combination of cells and growth factors, or modified cells to aid in the vascularization, innervation, and function of the penis [90–92]. These studies underlie the importance of a new aspect of regenerative medicine called regenerative pharmacology where growth factors are used alone or in conjunction with cells and/or biomaterials to stimulate tissues and organs to heal themselves in situ.

Repair of the Tunica Albuginea

Conservative treatments (compression, ice, pain medications) are effective in relieving pain in minor trauma of the tunica albuginea (TA), and drugs that promote blood flow (vasodilators), or anti-inflammatory drugs are effective in maintaining or restoring erectile and voiding function. In the instance of Peyronie's disease, and other diseases bending the penis, conservative treatments include verapamil, a calcium channel blocker, has been shown to disrupt collagen production. Interferon injections have been shown to have antifibrotic effects in the treatment of keloid scars and scleroderma, a rare autoimmune disease affecting the body's connective tissue [2, 93].

Surgical treatment of Peyronie's includes plaque excision or incision and grafting of the tunica albuginea with materials such as small intestinal submucosa, fascia, and pericardium [94]. All of these materials have drawbacks and alternatives are needed. The use of a bioengineered tissue would be able to overcome most of the limitations of current techniques while allowing for lasting results. Schultheiss et al. [95] isolated porcine fibroblasts from open fascia biopsies and

seeded them on decellularized collagen matrices. The seeded matrices were then cultivated in a bioreactor under in vitro multiaxial stress for 21 days. Static cultures without mechanical stress served as controls. Mechanically strained cultures of fibroblasts showed a homogeneous multilayer matrix infiltration and a regular cell alignment in the direction of strain axis after 7 days as well as increased production of extracellular matrix proteins compared to the static controls. Results suggest that in vitro conditioning may be needed to optimize the production of a suitable penile implant.

Similar work has been performed using an acellular bladder mucosal graft [96]. Acellular matrices were constructed from decellularized pigs' bladders. A segment of the tunica albuginea of nine rabbits was then excised, and the defect was covered with porcine bladder acellular matrix. Two months after implantation, the graft sites had excellent healing without contracture, and the fusion between the graft and the neighboring normal TA appeared to be well established. There were no significant histological differences between the implanted tunica and the normal control tunica at 6 months after implantation. Additional stem-cell therapies for Peyronie's disease are currently being tested [97] including novel growth factors and anti-scarring molecules [98] and adipose stem cells [99].

Conclusions

Penile repair or reconstruction is necessary for a variety of diseases, conditions, and injuries. Multiple treatment options are available, but many are not sufficient to restore full function of the penis or cause negative effects. Regenerative medicine opens new possibilities for penile reconstruction of structure and enhancement of function. New biomaterials provide improved microenvironments for cell growth and superior biomechanical properties compared to older biomaterials. Isolation of autologous adult progenitor cells and the ability to increase their plasticity pave the way to expand the cell numbers needed for construct fabrication and the implant strength. Increased understanding of the pathways that stimulate in situ tissue repair provides useful alternatives to replace or augment traditional regenerative medicine approaches to penile reconstruction.

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Modified Tissue Engineering Technique in Penile Augmentation using PLGA Scaffold

24

Zhong Cheng Xin

Introduction

The clinical diagnosis of microphallus (also called micropenis) is reserved for those men whose penile size is more than 2.5 standard deviations (SDs) below the mean for age. It is commonly associated with androgen insensitivity, severe hypogonadism, or, rarely, traumatic etiology. Although microphallus is a rare clinical entity, a substantial proportion of patients are troubled by their penis size, which may lead to psychological anguish with implications for the man's self-esteem and sexual relationships. Excessive concerns over the penile size might present as the "small penis syndrome (SPS)," an obsessive-compulsive state with body dysmorphic disorder or as part of a psychosis [1].

Traditional Approaches of Penile Augmentation

Endocrinotherapy is commonly used to treat microphallus, but it is not clearly indicated in cases of SPS. Although patient education may be sufficient to reassure some patients about the normality of their penile size, surgical correction with penoplasty may be contemplated for some patients with severe distress related to SPS. Demand for penile cosmetic surgery, penile lengthening, or penile widening continued to increase for several years. Although different techniques for augmentation phalloplasty have been reported in the medical literature, this issue is still highly controversial, and none of the proposed procedures has been unanimously approved. Penile girth augmentation can be achieved by various techniques, among which are liposuction injection, synthetic grafts, and autologous grafts.

Autologous fat injection may be performed as an outpatient procedure, but transplanted adipose tissue is eventually reabsorbed with long-term disappointing results [2]. Transplantation of non-autologous acellular matrix has many advantages, such as low immunogenicity, elimination of donor site morbidity, and a significantly shorter operation time; however, the degree of penis enlargement with this method is generally low, and the high price of these materials limits their clinical application [3–5]. Flaps are considered superior to grafts considering their uninterrupted blood supply. Previous study [6] has reported rotational flaps from the groin and latissimus, but the extensibility of these flaps and the substantial risk of donor site deformity tend to limit the utility of these approaches.

Foreign materials, such as paraffin balm, paraffin oil, mineral oils, and silicone, have been used to promise an improvement in penile size [4, 7–9]. These foreign materials are subcutaneously

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injected into the penis to induce granuloma formation. Granuloma formation, which is also known as lipogranulomas, is caused by a natural host response to walled off exogenous substances with multinucleated giant cell and chronic inflammatory cells. However, these granulomas are too large to be broken down naturally, and the result is a severely disfigured and swollen penis, which cannot achieve penile erection. Local complications of penile lipogranuloma include scarring, abscess formation, infection, ulceration, local migration, and cavernosal invasion, leading to functional impairment [7, 10]. Meanwhile, severe systemic complications such as foreign body embolization and organ infarct will result sudden death case [11].

PLGA Scaffold in Penile Augmentation

Tissue engineering is the use of a combination of cells, engineering and materials and methods, and suitable biochemical factors to restore, maintain, or improve tissue biological functions or replace a whole organ [12]. Scientific advances in biomaterials, stem cells, growth factors, and biomimetic environments have created unique opportunities to fabricate tissues in the laboratory from combinations of biomaterials, cells, and biologically active molecules. With the progress of tissue engineering technology, current advances in organ reconstruction or plastic surgery focus on fabrication of "live" biocompatibility grafts with various biomaterials. Ideal biomaterials should not only be biocompatible to cells but also should elicit bioactive cellular responses [13]. The biomaterials used to fabricate scaffolds in tissue engineering can be classified into two types: naturally derived materials (extracellular matrix, ECM) and synthetic polymers.

Previous studies have demonstrated the ability of ECM in the restoration or replacement of injured tissues [14]. The structural and functional components of the ECM allow adjacent cells to communicate with each other and with the extracellular environment. This communication plays a fundamental role in cell adhesion, spreading, proliferation, organ development, and damage repair [15–17]. However, scaffolds constructed entirely with naturally derived materials often have poor mechanical strength, which ultimately results in collapse after transplantation [18]. Synthetic polymers are promising scaffold materials due to the ability to control shapes and mechanical properties. In addition, synthetic polymers have been extensively studied as scaffold materials for its good mechanical properties, biodegradability, biocompatibility, and low toxicity [19, 20].

Poly(lactic-co-glycolic acid) (PLGA) is synthesized by means of ring-opening polymerization of two monomers, glycolic acid and lactic acid. Depending on the ratio of the two different monomers used for the polymerization, various forms of PLGA can be obtained (e.g., PLGA 75:25 identifies a copolymer whose composition is 75 % lactic acid and 25 % glycolic acid). PLGA is a synthetic copolymer which is used in a plenty of therapeutic devices approved by the Food and Drug Administration (FDA), owing to its biocompatibility and biodegradability. PLGA will undergo hydrolysis of its ester linkages in the body to produce the original monomers, lactic acid and glycolic acid. These two monomers are by-products of various metabolic pathways under normal physiological conditions. The body effectively deals with these two monomers, so there is minimal systemic toxicity associated with PLGA. Previous studies have shown that the degradation time of PLGA is determined by the ratio of the two monomers: the higher the percentage of glycolic acid, the shorter the time required for hydrolytic degradation. It is possible to regulate the polymer degradation time by altering the ratio of the two monomers which has made PLGA a common choice in the fabrication of a host of biomedical devices, such as grafts, sutures, prosthetic devices, and surgical sealant films.

Perovic et al. [21] have previously used PLGA matrix clinically for penile girth enhancement in 84 patients followed 1–5 years postoperatively (median 24 months). Among these, 70.24 %

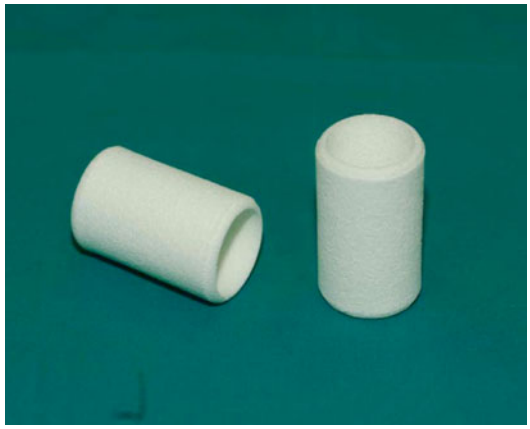

Fig. 24.1 Scaffolds before pretreatment for cell seeding (Cited from Perovic et al. [21])

presented penile dysmorphic disorder, and 25 patients (29.76 %) had a history of previously failed penile girth enhancement. Dry tube-shaped PLGA (Regen BiotechInc., Sungnam, Korea, Fig. 24.1) used in this study was 50 mm in length, 30 mm in inner diameter and 3 mm in thickness, and pore size 250–400 μm. The PLGA scaffold (Fig. 24.1) was pretreated by complete immersion into 75 % ethanol solution in aseptic condition before cell seeding. Fibroblast cells were harvested from biopsied scrotal dermal tissue and expanded in vitro. Suspended fibroblast cells were then seeded on pretreated PLGA scaffolds and incubated for 24 h.

After subcoronal incision and penile degloving, two-cell seeded PLGA scaffolds were adjusted and implanted into the space between dartos and Buck's fascia (Fig. 24.2). When the skin was noncompliant, scaffolds were placed under lifted neurovascular bundle. Penile skin was reconstructed following repair of dartos fascia. A compression dressing was left for 7–10 days. Antibiotics were administrated for the next 5 days. Two weeks after surgery, patients started to use vacuum device twice a day (5–10 min) during the first 6 months to prevent temporary penile retraction. Postoperatively, complications occurred as penile skin pressure necrosis in 2, wound infection in 2, and temporary seroma formation in 6 patients who started with sexual intercourse within 6 weeks after surgery, and all were treated conservatively. The mean size of

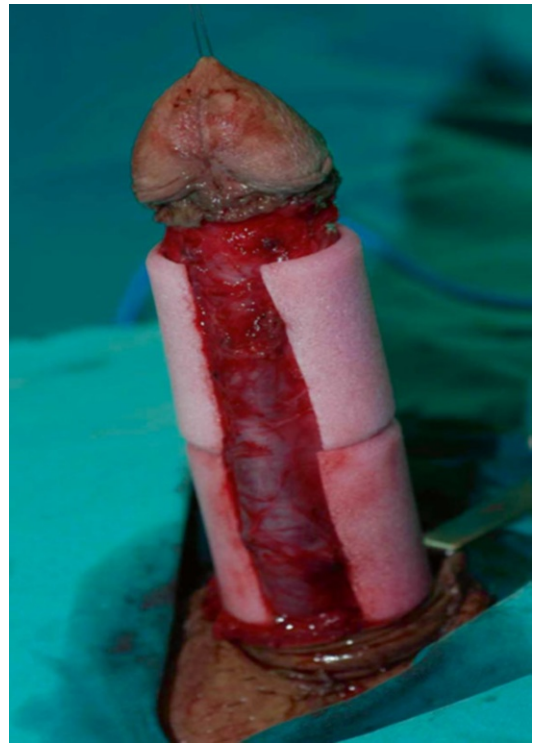

Fig. 24.2 Scaffold implantation between Buck's and dartos fascia in the case of compliant skin (Cited from Perovic et al. [21])

flaccid and erect girth gained was 3.15 ± 0.42 cm (range from 1.9 to 4.1 cm) and 2.47 ± 0.49 (range from 1.8 to 3.0), respectively. Overall, the mean self-scored genital appraisal in this study was 4.07 ± 0.71 (Range 1, very dissatisfied, to 5, excellent), and nearly two-thirds of patients were satisfied with penile girth in the flaccid and erect state after surgery.

A study conducted by Perovic et al. [22] has investigated the tissue remodeling after penile girth enhancement using autologous tissue with PLGA scaffold. In this study, PLGA scaffolds were provided by the same company (Regen Biotech, Korea). Scrotal dartos fascia was used to isolate primary cells: Cell suspension was then seeded into the scaffolds, rolled for 2 h to allow cell attachment, and incubated at 37 °C for 24 h. The surgical procedure of scaffold implantation was conducted as previously described [21]. After operation, all patients in this clinical study were satisfied with the quality of their sex life and

penile girth in flaccid and erection state. In addition, all patients are satisfied with their penile appearance with no macroscopic scar and postsurgical complications.

Cytological identification documented that the expanded dartos cells were 25.8 ± 3 % CD34 positive and 25.5 ± 2 % α-actin positive. Histologic analysis showed that residual chronic inflammatory infiltrates surrounding scaffold material were found after following up 12 months, with fibroblast-like cell hyperplasia. After 24 months of following up, PLGA scaffold was reabsorbed and replaced with a highly vascularized connective tissue, with no residual inflammatory signs and closely resembling the normal deep human dartos fascia. One of the major challenges in tissue engineering is adequate blood supply. Interestingly, in 12-month biopsies, small capillaries with blood cells were detected inside or around the residual amorphous scaffold-like material. In these capillaries, CD34-positive cells among layers of α-actin-positive cells were detected around luminal amorphous material, still surrounded by occasional giant cells and scattered inflammatory cells. Different development stages of the new vessel-like structures could be observed even in the same area. The above results suggested that transplantation of dartos cells favored the development of vascular structures similar to those of adult penile body.

Maxpol-T Scaffold in Penile Augmentation

The Maxpol-T cytoskeleton, a high-interval-porosity sponge material mainly composed of PLGA in a 75:25 ratio of lactide to glycolide, is similar to human dermis. Wu et al. have demonstrated that fibroblasts grew well after seeded on Maxpol-T in vitro. In addition, they also demonstrated that the autologous fibroblast-coated Maxpol-T was effective and safe for penis girth enhancement in a rabbit model. The penile girth enhancement is of greater general interest concerns because majority of female report their sexual satisfaction related to penis width [23].

We have also conducted a human clinical trial to evaluate the clinical safety and efficacy of the biodegradable Maxpol-T scaffold coated with autologous fibroblasts for penile girth enhancement [24]. 69 patients (from 19 to 52 years old) complained of dissatisfied penis size and clinically diagnosed with SPS were enrolled. Average preoperative penile girth was 8.18 ± 0.83 cm (range from 5.50 to 11.00 cm) and 10.26 ± 1.22 cm (range from 8.62 to 13.48 cm) in the flaccid and erection state, respectively. Human fibroblasts were harvested from a biopsied scrotal dermal tissue and expanded in vitro. The inner diameter of the Maxpol-T scaffold (Maxgen Co Ltd, Mianyang, China) was 26 mm, exterior diameter was 32 mm, and length was 50 mm. The dry Maxpol-T scaffold was hydrated by immersion into 75 % ethanol solution in aseptic conditions. The ethanol solution was removed completely by repeated washing with phosphate-buffered saline solution (PBS) and serum-free culture medium. Suspended autologous fibroblasts were then seeded into the scaffold and incubated at 37 °C for 2 h before transplantation. For penis enlargement operation, a circumcising incision was made, and the foreskin was degloved to the penile base to expose the tunica albuginea. The seeded Maxpol-T graft was shaped according the penile size and transplanted into the space between the side fascia and tunica albuginea. The Buck's fascia and penile skin were closed with absorbable suture (Fig. 24.3). Antibiotics were administrated for 1 week, and patients were advised to avoid sexual activity until 6 weeks after the operation.

The mean penile flaccid girth was 11.79 ± 1.18 cm at 1 month after operation, 12.20 ± 1.24 cm at 3 months, and 12.19 ± 1.27 cm at 6 months, respectively. The mean penile erection girth at 1, 3, and 6 months postoperative was 14.29 ± 1.19 cm, 14.75 ± 1.30 cm, and 14.28 ± 1.23 cm, respectively. Penile girth at flaccid state and erect state was significantly increased postoperation ($P < 0.01$; Figs. 24.4 and 24.5). However, no length enhancement was observed in flaccid state and erected state at 1, 3, and 6 months after operation. No rejection reaction occurred in this clinical trial. In addition, no

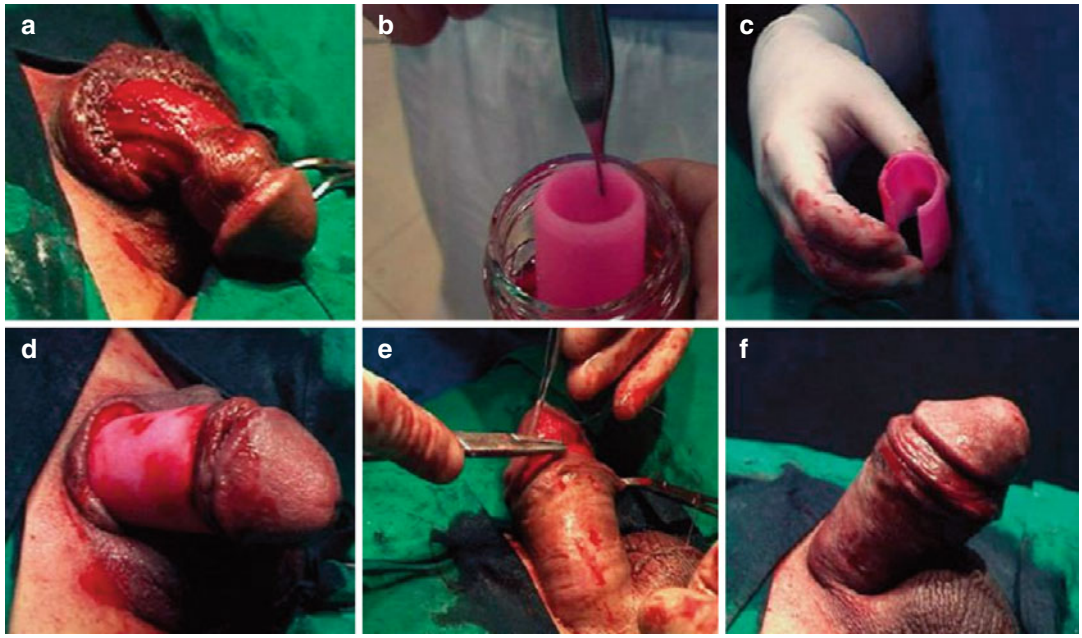

Fig. 24.3 Transplantation of autologous fibroblast seeded Maxpol-T graft in the space between the side fascia and tunica albuginea. (**a**) The penis skin degloved to the penis root, exposing the tunica albuginea. (B) Taking the graft from sterile chamber. (**c**) Modeling graft. (**d**) Transplanted the graft in the space between the side fascia and tunica albuginea. (E) Closed fascia and skin layers. (**f**) Post surgery (Cited from Jin et al. [24])

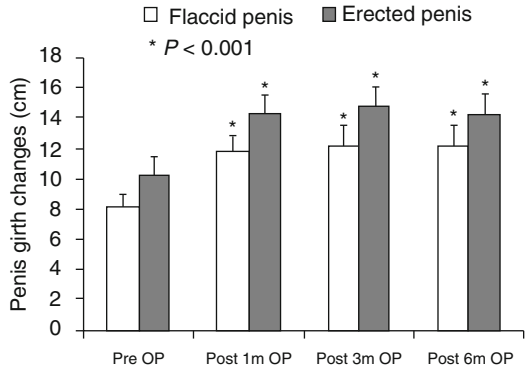

Fig. 24.4 Penis girth changes in the flaccid and erect state before (pre-op) and 1, 3, and 6 months after (post-op) surgery. Penis girth in the flaccid and erect state at 1, 3, and 6 months postoperation increased significantly compared with preoperation (Cited from Jin et al. [24])

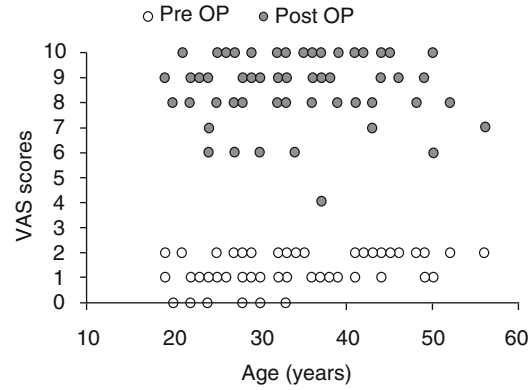

Fig. 24.5 Patient satisfaction evaluated according to the visual analogue scale (VAS) (a proxy measure of satisfaction with penile size) before surgery (pre-op) and 6 months postoperation (post-op) (Cited from Jin et al. [24])

postoperative laboratory abnormalities were noted with respect to hematologic, electrolyte, and liver function assays. In this study, 94.2 % patients reported satisfaction with at least 2 cm penile girth enhancement. Erectile function and penile sensitivity did not change after surgery. All these results indicated that this new tissue engineering approach for penile girth enhancement appeared to be safe for patients with low morbidity and a low incidence of complications.

The IIEF-5 evaluation of erection function for all patients, preoperation and postoperation, did not vary. All men had normal erectile function (IIEF-5 score .22) in the inclusion

criteria, and all men maintained IIEF-5 scores .22 pre- and postoperation. Three patients (4.3 %) experienced prolonged, subcutaneous edema for about 12 weeks. In 3 other patients (4.3 %), pinpoint erosion at the suture area was noted; these cases were treated by medical therapy. Among them, in 2 patients, penile subcutaneous fluid was absorbed after taking levofloxacin (0.2 g, twice a day, orally, 10 days), whereas one other patient was given oral azithromycin tablets for 7 days to control his infection and then healed after debridement in 10 days.

Summary

Autologous cells composited with biodegradable PLGA scaffolds are a new and promising treatment option for achieving real penile girth enhancement. The clinical trials with this procedure showed a significantly lower incidence of complications when compared with previously established procedures. Other advantages are easy operation, low morbidity, and reduced operative time. The clinical advantage may derive from neovasculogenesis, fibroblast-like hyperplasia, and collagen accumulation in the scaffold-induced connective tissue. However, long-term studies are still recommended for its future clinical application.

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Modified Tissue Engineering Techniques Using Stem Cells

25

Heung Jae Park and Kyung Hyun Moon

Introduction

Penile reconstruction may be required under some conditions such as penile malignancy, trauma, congenital genitourinary anomalies, and Peyronie's disease (PD). The traditional penile reconstructive procedures cannot fulfill to restore a functionally and cosmetically satisfactory penis and have complications such as immunological rejection and psychological problems. One of the major structures of the penis is the corpus cavernosum. The penile corpus cavernosum is composed of sinusoids that are surrounded by the layers of endothelial cells (ECs) and smooth muscle cells (SMCs). Erectile function of penile corpus cavernosum is dependent on these two kinds of cells [1]. The therapeutic uses of stem cells (SCs) and tissue engineering (TE) techniques are emerging in urology. SCs are undifferentiated cells capable of proliferation, self-renewal, and differentiation into different cell types including ECs, SMCs, Schwann cells, and neurons [2]. SC therapy for penile tissue regeneration (TE) might replenish the depleted ECs and SMCs. Therefore, TE for penile tissue regeneration using SCs may have a huge potential and could be a novel treatment option for ideal penile reconstruction.

General Aspects of Tissue Engineering and Stem Cells

TE is the combination of cell biology, materials science, and engineering to devise therapeutic strategies. TE, which aims to replace, repair, or enhance biological functions of damaged tissues or organs, offers the opportunity to address this terrible situation. TE generally falls into two categories: acellular techniques, which require the use of acellular matrices as a scaffold to regenerate for proper orientation and direction of new tissue growth; and cellular techniques, which can be expressed as matrices with cells. Acellular tissue matrices are usually prepared by removing cellular components from tissues or by manufacturing artificial scaffolds for eventual implantation via mechanical and chemical means [3]. Various cells which can be heterologous, allogeneic, or autologous can be used as sources of biological materials for matrix-based TE. Most current strategies for TE prefer to use autologous cells from the diseased organ of the host to eliminate the risk of rejection. However, for many patients with severe

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end-stage organ failure, it is often difficult to harvest normal cells enough for expansion and transplantation. In this situation, SCs can be used successfully as sources of biological materials for TE. SCs can expand and differentiate into desired tissue types, and these abilities of SCs make them an attractive alternative cell source for regenerative medicine applications. SCs are broadly classified into embryonic SCs (ESCs) and adult SCs. ESCs can differentiate into all three germ layers of ectoderm, mesoderm, and endoderm. However, ESCs do not differentiate into extraembryonic tissue and have the possibility of forming teratocarcinoma. The sources of traditional human ESCs are human embryos and have significant ethical problems. These obstacles have elicited the search for alternative SC sources including adult SCs. Adult SCs are obtained from developing germ layers or their respective adult organ. Adult SCs can renew itself and differentiate into specific cell types and have the advantage of avoiding the ethical concerns of ESCs. In addition, induced pluripotent SCs (iPSCs) were generated directly from adult cells in 2006 [4]. Since iPSCs could be obtained from adult cells, they not only have the advantage of avoiding the ethical concerns of ESCs but can be made in a patient-matched manner. These unlimited supplies of autologous SCs could be transplanted without the risk of immune rejection.

SCs as Sources of Biological Materials for Penile Reconstruction

Various SCs such as muscle-derived SCs (MDSCs), mesenchymal SCs (MSCs), neural crest SCs (NCSCs), adipose-derived SCs (ASCs), and ESCs and so on are utilized for investigations into cellular therapeutics in penile reconstruction [5].

MDSCs

MDSCs are adult SCs found in muscle tissues. MDSCs are easily obtained from skeletal muscle tissue via a minimally invasive procedure, such as muscle biopsy. MDSCs have been investigated extensively because they have active prolonged proliferation, low immunogenicity and carcinogenic risk, and the ability to differentiate into various cell lineages after implantation into different organs [6]. MDSCs have been asserted to generate SMCs in vitro and in vivo [7, 8]. It was reported that MDSCs implanted into the corpora cavernosa of aged rats converted into SMCs and restored erectile function in 2008 [8]. This report confirmed the potential efficacy of SCs to substitute cavernosal SMCs that were damaged in the penis during the aging process. MDSCs could also be seeded onto three-dimensional acellular corporal collagen matrix (ACCM) scaffolds and reconstituted functional corpus cavernosum in vivo in 2010 [9]. MDSCs were obtained from male rabbit muscle tissue by a preplate technique [10, 11]. ACCMs were obtained from rabbit penis using the established decellularizing technique using 2 % Triton X-100 and 0.1 % ammonium hydroxide (Fig. 25.1). MDSCs were seeded on ACCMs, and MDSC-seeded ACCMs were implanted with tunica albuginea of rabbit (Fig. 25.2). MDSCs seeded on ACCMs developed tissue similar to native normal corpus cavernosum [9]. However, the formation of capillaries in the tissue-engineered corpus cavernosum (TECC) was less than that in native corpus cavernosum. Vascular endothelial growth factor (VEGF) is a signal protein produced by cells that stimulates functionally significant vasculogenesis and angiogenesis. Intracavernosal injection of VEGF could increase the expression of endothelial

Fig. 25.1 A gross view of the acellular corporal collagen matrices (Adapted from Ji et al. [9])

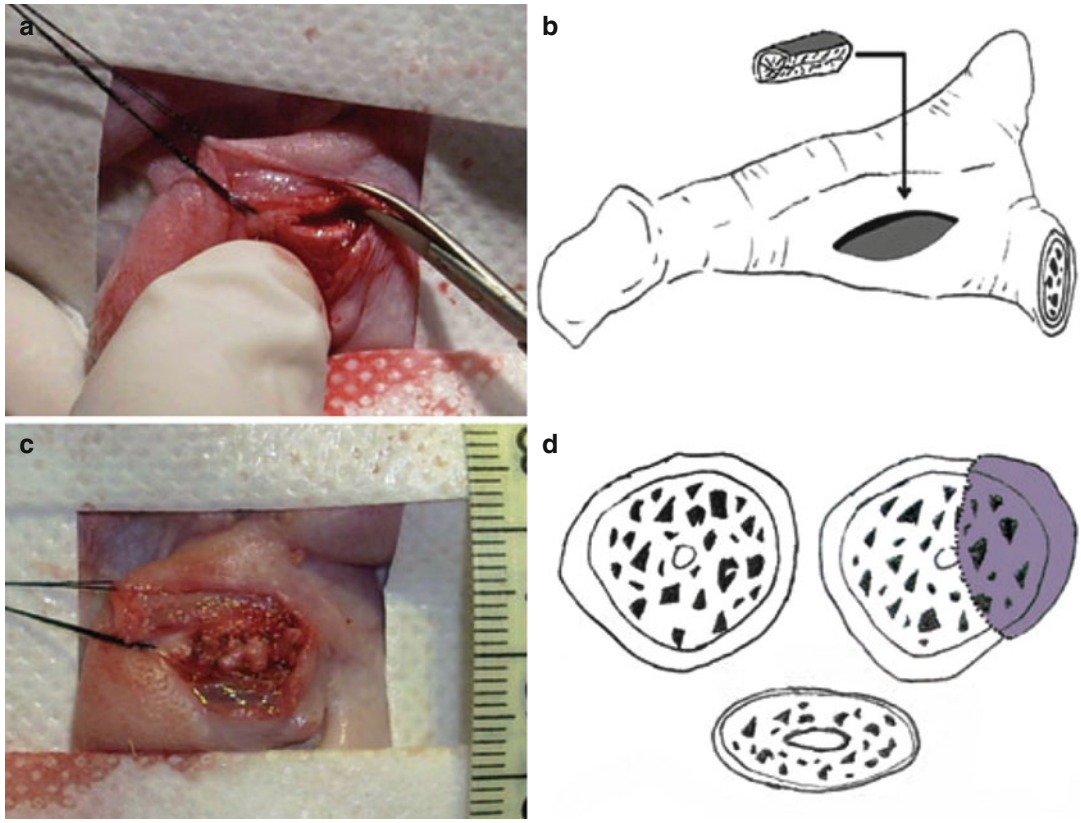

Fig. 25.2 Transplantation of tissue-engineered corpus cavernosum and acellular corporal collagen matrices. (**a**, **b**) Anastomosis between the graft and tunica albuginea; (**c**) operative schematic diagrams of transplantation; (**d**) transection of operative site (Adapted from Ji et al. [9])

nitric oxide synthase (NOS) and the percentage of corpus cavernosal smooth muscle and help to improve erectile function. In order to investigate the effect of VEGF, MDSCs were also obtained from rabbit muscle tissue by a preplate technique, and human VEGF lentiviral gene vector which contained a green fluorescent protein was used. MDSCs with VEGF were seeded on ACCMs, and these MDSC-seeded ACCMs with VEGF greatly increased ECs, SMCs, and especially the capillary density in building the TECC compared with simple MDSCs seeded on ACCMs [12].

MSCs

MSCs are multipotential SCs in the bone marrow. They can differentiate into various cell types such as osteoblasts, chondrocytes, and adipocytes. MSCs secrete many cytokines and growth factors that have both paracrine and autocrine activities and have beneficial effects on damaged or diseased tissue. MSCs are isolated from the bone marrow by aspiration. MSCs can be differentiated into SMCs and ECs, resulting in increased vascularity and improved cardiac function in a canine chronic ischemia model [13]. Human MSCs also have the potential to differentiate toward ECs and SMCs in rat corpus cavernosum [14]. Human MSCs were obtained from fetal spinal vertebrae and implanted into the adult rat corpus cavernosum. This corpus cavernosum was harvested 2 weeks after implantation. This MSC-implanted rat penis differentiated toward SMCs and ECs. MSCs also restored erectile function in cavernous nerve injury (CNI) mice [15]. Mouse clonal MSCs were obtained from the tibiae and femurs of 5-week-old mice by using subfractionation culturing method

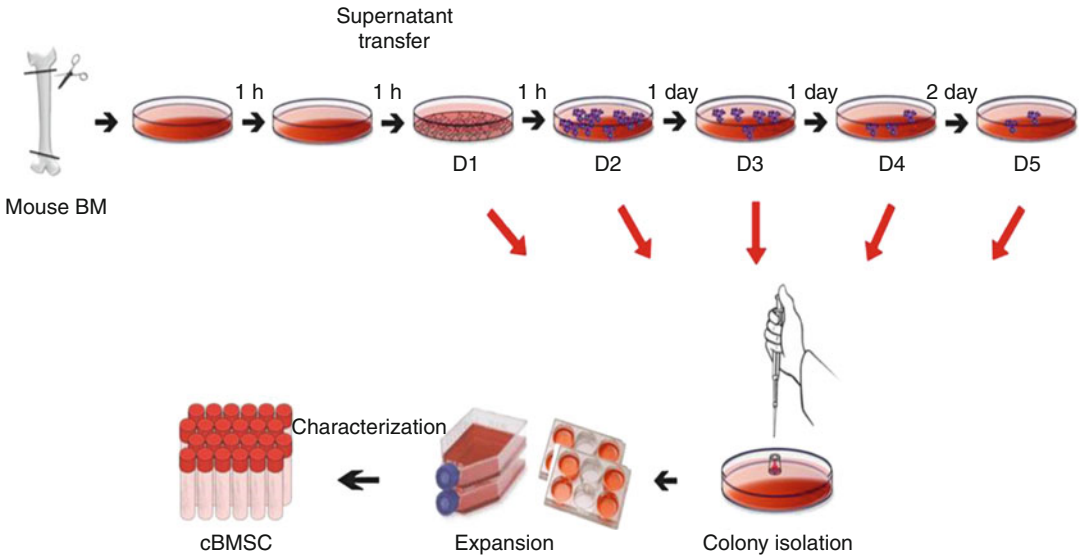

Fig. 25.3 Flow diagram of the subfractionation culturing method used to establish mouse clonal bone marrow-derived stem cell (cBMSC) lines. Mouse bone marrow (BM) aspirate was mixed with Dulbecco's Modified Eagle's Medium low glucose and plated onto a 100-mm cell culture dish. After 2-h incubation, only the supernatant was transferred to a new dish. This procedure was repeated once more, and the supernatant was then transferred to subsequent cell culture dishes (D1 to D5) with a 1- or 2-day interval as shown. Each dish was then incubated until single-cell-derived colonies appeared. When colonies of cells were large enough, they were transferred to a six-well plate and then expanded to larger flasks for freezing and further study (Adapted from Ryu et al. [15])

(Fig. 25.3), and cavernous nerves of 12-week-old mice were crushed using a nonserrated hemostat. These clonal MSCs were injected into the intraperitoneum and the midportion of the corpus cavernosum of old mice. The injections of clonal BMSCs resulted in marked restoration of cavernous EC and SMC content and increased penile neuronal NOS and neurofilament content in CNI mice. As a result, erectile function in CNI mice was successfully restored after the implantation of clonal BMSCs. MSCs might become a new treatment option for restoring normal function of penile corpus cavernosum.

NCSCs

NCSCs are the progenitor cells and can be differentiated into various cell types including neurons, Schwann cells, melanocytes, smooth muscle cells, and bone cells [16, 17]. NCSCs generate a wide variety of differentiation products including neurons, glia, skeletal muscle cells, cartilage, bone, connective tissue, and especially SMCs and ECs [18–22]. NCSCs can be obtained from not only in gestation embryonic tissues but also in adults including dorsal root ganglia, gut, heart, sciatic nerve, bone marrow, carotid body, cornea, and skin [19]. Several investigators reported corpus cavernosum repair by using NCSCs. NCSCs were isolated and purified from fetal human dorsal root ganglia. These human MSCSs were implanted into the corpus cavernosum of 10-week-old male rats. Human NCSCs implanted into the rat corpus cavernosum differentiate into ECs or SMCs [23]. NCSCs may be worth an ideal cell source for reconstruction of the corpus cavernosum by restoring ECs and SMCs. However, clinical application is limited for the lack of the source of these cells.

ASCs

ASCs can secrete cytokines and growth factors at an injured or diseased tissue, repair damaged

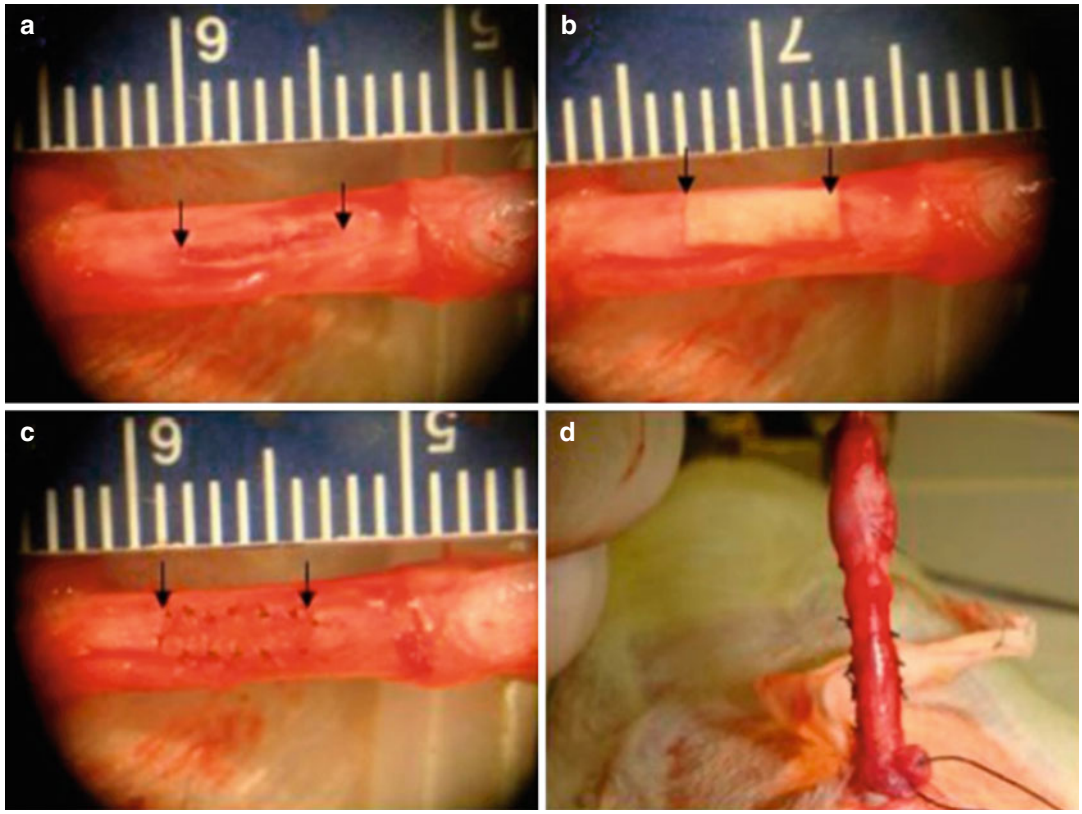

Fig. 25.4 SIS-ADSC grafts and reconstruction surgery of TA. (**a**) Rat penis middle section was chosen as the surgery site. Rats underwent first-stage surgery, which included a 5-mm incision (*arrows*) on both sides of the TA. (**b**, **e**) A 10-mm^2 SIS and stem cell-seeded SIS (*arrow*) were interpositioned and sutured with 8-0 nylon for the third or fourth groups. (**f**) All excisions for tunica grafting were performed laterally to protect the dorsal cavernous nerves from injuries (Adapted from Ma et al. [26])

tissue, and promote cellular differentiation along the required lineage pathway [24]. ASCs can easily be isolated from fat tissue of patients via minimally invasive liposuction surgery and be cultured and expanded rapidly. ASCs may also have the potential to reconstruct tunica albuginea (TA). Porcine small intestinal submucosa (SIS) patch is a multilayered xenograft material derived from the submucosa of swine intestine, which has been used in the reconstruction of various tissues and organs, especially TA reconstruction [25]. ASC-seeded SIS patches were cultured and formed epithelium on the SIS graft. ASCs-SIS grafts were implanted into the rat penis via TA incision through both lateral sides of the TA (Fig. 25.4) [26]. ASCs-SIS grafts preserved the corpus cavernosum significantly and maintained better erectile response compared with grafts with SIS alone. ASCs-SIS grafts resulted in an increase in mean penile diameter and restored neuronal NOS, endothelial NOS, and VEGF expression [26]. ASCs-SIS grafts could be efficiently used for TA reconstruction. Peyronie's disease (PD) is a connective tissue disorder of the penis due to growth of fibrous plaques in the TA. A variety of treatments have been used, but none have shown adequate effect. SC therapy may benefit men with PD in the future, although the investigation using SC therapy for PD is still in its infancy. The creation of a rat experimental model in the active phase of PD was accomplished by TGF-β1 injection into the penis of rats, and the penis displayed eventually extensive tunica-corporeal fibrosis and elastosis, namely,

penile plaques of TA. Injection of ASCs into TA prevented the development of these penile plaques and preserved overall structure and collagen type III and elastin protein expression of the corpus cavernosum [27]. Treatment of ADSCs into the TA during the active phase of PD may prevent the formation of penile plaques in the TA and corpus cavernosum.

ESCs

ESCs are pluripotent stem cells derived from the inner cell mass of a blastocyst, an early-stage preimplantation embryo. Although ESCs have their ability to differentiate into any cell type and to propagate, investigation has delayed because of ethical and legal issues. ESCs were isolated from blastocyst of female rats and transfected with brain-derived neurotrophic factor (BDNF) to induce to differentiate into neural cells. Male rats had bilateral CNI, and these ESCs transfected with BDNF were implanted into the corpus cavernosum of CNI rats. These ESCs improved cavernous nerve regeneration and erectile function [28].

Conclusions

The emerging applications of TE are quickly expanding over subdivisions of urology. TE and SC researches continue to search for novel therapeutic strategies of tissue replacement and regeneration in genitourinary organs including penile disorders. A wide range of SCs have been investigated preclinically and have shown a high potential in penile reconstruction. Although the clinical trial is very rare, the promising results of preclinical studies and continuous research represent the hope of treating various penile diseases with tissue engineering techniques using SCs for penile reconstruction. We must also make certain the safety and efficacy of SC application before the clinical trial of SC therapy in humans. Recent remarkable progress proposes that TE of the penis including SC therapy may be applied soon in clinical fields.

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Penile Reconstruction in Peyronie's Disease

26

Ji-Kan Ryu and Jun-Kyu Suh

Introduction

Peyronie's disease (PD) is a relatively common disorder affecting 3.2–8.9 % of the male population and is characterized by localized fibrotic plaques in the tunica albuginea [1–3]. These plaques impede the expansion of the tunica albuginea during erection, which results in penile bending and often pain. Penile deformities include curvature, shortening, narrowing or hourglass deformity, and hinge effects or penile instability, resulting in difficulty with intromission. Penile pain with erection is a common and usually disappears in most patients within 6–18 months after onset. Repeated trauma to the penis during the sexual intercourse and subsequent inflammatory responses and aberrant wound healing in genetically susceptible individual are known to be involved in the fibrotic processes in tunica albuginea [4, 5]. However, the molecular mechanisms responsible for chronic and progressive fibrosis are not yet completely delineated, and the medical treatments currently available fail to alter the progression of PD. So far, surgical intervention is the only efficacious treatment for PD [6, 7]. A variety of surgical approaches may be considered depending on the severity of penile deformity and preoperative erectile function. There are accumulating data in regard to outcomes associated with established surgical procedures and modification of these procedures. Surgical correction should be offered based on sound indications, and preoperative surgical consent is imperative to reconcile patient expectation. In this chapter, we will introduce the different surgical approaches and procedures, including tunical shortening or lengthening procedures, with particular emphasis on surgical techniques and address critical issues for surgeons to administer the best treatment outcomes.

General Considerations of Surgical Treatment for Peyronie's Disease

The course of PD may be divided into an early or acute inflammatory phase (active phase) and a later or chronic phase (stable phase). During the early phase of the condition, there may be penile pain with erection and deformity progression, whereas penile pain typically disappears and deformity usually stabilizes in the late phase. Spontaneous resolution of penile deformity is quite rare and occurs only in 3.2–12 % of patients [8, 9]. For the majority of cases, the disease may progress or stabilize.

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Although conservative treatment for PD can resolve painful erections, only a small proportion of patients experience significant resolution of penile curvature. The purpose of surgery is to correct penile deformity and allow satisfactory sexual intercourse. Surgical correction is usually indicated when the associated penile deformity failed to respond to conservative treatment and impedes adequate penetration. Surgery should be offered in patients with stable disease for at least 6 months or at least 1 year from the time of onset and no penile pain with erection. In addition, patients who have extensive plaque calcification and who want rapid and reliable results may also be a good candidate for surgery [10, 11] (Table 26.1).

A number of factors including patient understanding, physician's experience, potential benefit and adverse events, and cost must take into consideration prior to surgical correction. Proper selection of patients along with appropriate surgical technique and informed consent are extremely important, because these factors are critical for good therapeutic outcomes allowing the patient to resume normal sexual activity. Preoperative consent should include the possibility of persistent or recurrent curvature, penile shortening, decrease in penile rigidity, some loss of penile sensation, and potential palpation of knots and stitches (Table 26.2). Decrease in penile sensation is usually transient and improve over time, unless there is significant neurovascular injury. A majority of patients will require postoperative penile rehabilitation, such as the use of phosphodiesterase (PDE)-5 inhibitors and penile massage or stretching, and this should also be discussed preoperatively. Clear discussion of the potential risks and realistic outcomes of selected surgical procedures is critical to set up patient's expectation and postoperative satisfaction.

Table 26.1 Indications for surgical treatment

Stable disease
At least 3 or 6 months with stable deformity and no pain on erection
At least 1 year from the time of onset
Inability to engage in coitus second to deformity
Failed conservative treatment (medical or minimally invasive therapy)
Extensive plaque calcification
Wants the most rapid and reliable results

Table 26.2 Preoperative counseling consent

Should discuss patient's expectations, alternative treatment modalities, and complications and outcomes of surgery
Persistent or recurrent curvature (6–10 %)
Surgical goal: functional penile straight (residual curvature less than 20°)
Penile shortening
More common in plication surgery than in grafting surgery
Decrease in erectile function
More common in grafting surgery than in plication surgery
Reduction in penile sensation
Usually resolve spontaneously
Palpation of knots and stitches
Penile plication by using nonabsorbable suture materials

In general, three different surgical procedures, including tunical shortening procedures, tunical lengthening procedures, and penile prosthesis implantation, are used for PD patients. Because PD patients have heterogeneous natures and variable presentations, no single surgical procedure has emerged as the standard of care. We have to choose proper techniques depending on degree and complexity of curvature, preoperative penile length and estimated loss of length after surgical correction, and baseline erectile function. Men with good erectile function or erectile dysfunction (ED) that responds to medical treatment are candidate for penile reconstructive surgery using either tunical shortening or lengthening procedures. Tunical shortening procedures include the Nesbit procedure and the modifications of this technique, such as Yachia procedure and penile plication, performed on the non-affected convex side of penile plaque. Tunical lengthening procedures are performed on affected concave side of the penis with the use of a graft. Penile prosthesis implantation should be reserved for men with PD and ED that is not responding to pharmacologic treatment (Table 26.3). When surgical correction

Table 26.3 Surgical treatment options

No ED or ED responsive to pharmacotherapy
Tunical shortening procedures (shortening of convex side)
Nesbit procedure
Yachia procedure
Penile plication
Tunical lengthening procedures (lengthening of concave side)
Plaque incision (or partial excision) and grafting
Autologous graft
Allograft
Xenograft
ED nonresponsive to pharmacotherapy
Penile prosthesis implantation

ED erectile dysfunction

is planned, we usually recommend duplex penile Doppler ultrasonography with intracavernous injection of a vasoactive agent in all patients to assess preoperative erectile quality, penile curvature, and plaque calcification objectively.

Tunical Shortening Procedures

The Nesbit procedure was first introduced in 1965 for the correction of congenital penile curvature [12, 13] and was also applied for the treatment of PD [14]. Small transverse ellipses of the tunica albuginea are excised on the convex side and then the defect is closed. Alternatively, Yachia has introduced modification of Nesbit plication technique [15]. Instead of excising tunica albuginea, a full-thickness longitudinal incision was made at the contralateral side of penile plaque and closed horizontally in the Heineke-Mikulicz fashion. Lue and colleagues have described a 16-dot plication method by use of multiple plication sutures with nonabsorbable suture materials [16]. Plication of the tunica albuginea is the minimally invasive technique that can be done under local anesthesia. It obviates extensive dissection of neurovascular bundle or urethra. Although penile plication is a simple and minimally invasive technique, the authors do not prefer this technique, because sometimes it does not ensure long-term tensile strength and we occasionally experienced recurrence after surgery.

Tunical shortening procedures are indicated in men with curvature less than 60–70°, no complex penile deformity, such as hourglass or hinge effect, and adequate preoperative penile rigidity with or without pharmacotherapy. In addition, this technique may be considered in men with adequate penile length and ideally predicted loss of penile length should be less than 20 % of erect penile length. Tunical shortening procedures are relatively simple and minimally invasive techniques and we can preserve potency in most cases. The drawbacks of any tunical shortening procedures for PD are that it does not address penile shortening because the plication procedures shorten the unaffected long side of the tunica albuginea and therefore the loss of penile length is inevitable. However, the loss of penile length is only 1–1.5 cm in a majority of patients and rarely causes difficulty in intromission. Patients usually complain of the decrease in penile length as greater than the actual loss of the length. Therefore, it is fundamental to measure and describe pre- and postoperative penile length. The loss of penile length can be exacerbated when penile curvature is greater than 60°, and therefore proper patient selection is important. Tunical shortening procedures do not correct complex penile deformity and may worsen hourglass deformity and hinge effects. Moreover, in case of penile plication which utilizes nonabsorbable suture material, there may be pain associated with the palpable knots (Table 26.4).

Review of the previously published article suggests that penile straightening with a variety of tunical shortening procedures is reported in 85–100 % of patients, the prevalence of new ED is 0–13 %, and decrease in penile sensation is 4–21 % with follow-up of up to 89 months [11]. Overall, tunical shortening procedures are relatively simple, safe, and effective method to correct PD with durable outcomes and have acceptable complications. There is no clear evidence that one tunical shortening technique is

Table 26.4 Indications for tunical shortening procedures

Indications
Curvature <60–70°
No destabilizing hourglass deformity or hinge effect
Predicted loss of penile length <20 % of erect penile length
Advantages
Simple and minimally invasive
Preserve potency in most cases
Disadvantages
Loss of penile length
Suitable for small and unidimensional curves
May worsen narrowing or hinge effect

Table 26.5 Indications for tunical lengthening procedures

Indications
Curvature >60–70°
Destabilizing hourglass deformity or hinge effect
Extensive calcification
Good preoperative erectile function
Advantages
Penile length preservation
Disadvantages
Requires second incision (autologous graft) and longer operation time
Requires more skill
Risk of post-op ED

superior to other techniques, and the choice of technique should be employed based on the surgeon's experience.

Tunical Lengthening Procedures

Tunical lengthening procedures include plaque incision or excision in the affected side of the tunica albuginea to increase the length of the concave side and then tunical defect is covered by a graft. Plaque incision with H- or double Y-incision at the area of maximum curvature is more preferred than plaque excision because extensive plaque removal may induce high rate of postoperative ED due to venoocclusive dysfunction [17]. Partial plaque excision may be required when plaque causes severe indentation or if there is severe plaque calcification.

Tunical lengthening procedures may be considered in patients with curvature greater than 60–70°, destabilizing hourglass deformity or hinge effect and extensive plaque calcification. Most importantly, the patient must have good baseline penile rigidity. Even if the patient has suboptimal penile rigidity that respond to pharmacotherapy, the surgeon should fully instruct to the patients for the possibility of deterioration in erectile function postoperatively, which may not respond to oral PDE5 inhibitors or intracavernous injection therapy and ultimately require penile prosthesis implantation. Although this technique may preserve penile length, it requires additional incision to procure graft materials (autologous grafts), more skill, and longer operation time than tunical shortening procedures. As stated above, the risk of postoperative ED is relatively high in tunical lengthening procedures (Table 26.5). Besides preoperative erectile function, it has been reported that age more than 55 years and venoocclusive dysfunction on duplex penile Doppler ultrasonography with a resistive index of less than 0.8 are also regarded as potential predictors of postoperative ED [18–20].

The ideal graft material should be readily available, pliable, compliant, and inexpensive. It also has low risk for infection and antigenicity and minimal tissue reaction. Unfortunately, however, no one material is capable of meeting all these criteria. A number of graft materials including autologous grafts, allografts, and xenografts are currently in use (Table 26.6). There is no solid evidence to support the use of one graft material over another with regard to surgical outcomes except synthetic materials. A variety of autologous grafts have been used, including dermis, vein (saphenous vein, dorsal penile vein), buccal mucosa, proximal crura, tunica vaginalis, fascia lata, temopralis fascia, and prepuce. The graft material should be prepared at least 20 % larger than the measured tunical defect. Allografts or xenografts, including pericardium, small intestinal submucosa, and dermis from cadaver or animals, have also been introduced. The processed human and bovine pericardium (Tutoplast™, IOP Ophthalmics, Costa Mesa, CA, USA) and porcine small intestinal submucosa

Table 26.6 Grafting materials

Autologous graft
Dermis, vein (saphenous, dorsal penile), buccal mucosa, proximal crura,
Tunica vaginalis, fascia lata, temporalis fascia, prepuce
Allograft
Cadaveric pericardium, fascia lata, dura matter, dermis
Xenograft
Porcine small intestinal submucosa, bovine pericardium, porcine dermis
Synthetic materials[a]
Gore-Tex
Dacron

[a]Not recommended

grafts (Surgisis ES, Cook Urological, Spencer, IN, USA) are one of the most commonly used grafts in these days. The processed human and bovine pericardium has an advantage of less contraction than small intestinal submucosa grafts, which is known to contract up to 25 % after surgery [21]. A pericardial graft is usually trimmed to approximately 10 % greater than the measured tunical defects [22, 23]. Synthetic materials, such as Dacron and Gore-Tex, are no longer recommended because of severe inflammatory reaction, fibrosis, and the risk of infection. Although the use of autologous grafts is ideal due to the natural source of the material, however, it requires an additional incision, increasing a risk of donor site complications, and it takes longer operation time. Therefore, the use of "off-the-shelf" allografts or xenograft may be advantageous because there is no side effects related with graft acquisition and they can reduce operation time. However, some patients may be reluctant to use cadaveric source of grafts and do not accept animal source of graft material due to the religious reasons. Therefore, it is essential to discuss with patients about which type of grafts should be selected. And then the final choice of the type of graft material is based on the surgeon's preference and experience, and cost-effectiveness.

Common complications of tunical lengthening procedures with grafting include persistent penile curvature or curvature recurrence, graft contracture, decrease in penile sensation, neurovascular injury, and ED [22, 24]. Review of the previously published article suggests that penile straightening with a variety of tunical lengthening procedures is reported in 74–100 % of patients, the prevalence of new ED is 22–24 %, and recurrent or persistent curvature is 8–12 % [11].

Surgical Techniques

We have already discussed about the indications of reconstructive surgery for PD and the type of surgical procedures based on the degree and complexity of penile curvature and preoperative erection function. In this section, we are going to focus on a variety of surgical skills for the correction of penile deformity in a step-by-step manner.

Patient Preparation

Before surgery, we usually administer one dose of a first-generation cephalosporin. The operation field is depilated as usual manner, and Betadine scrub to lower abdomen and genitalia is performed for 10–15 min. In most cases, the patient is placed in supine position. If we consider saphenous vein as a graft material, the lower extremities should be placed in frog-leg position. Although a majority of reconstructive surgery for PD is performed under general anesthesia, penile plication may be done under local anesthesia.

Skin Incision

We prefer to use circumcision incision and the shaft of the penis is then degloved to its base, which ensures good exposure for majority of lesions. When we deglove penis, the incision should be included full layer of dartos fascia just superficial to Buck's fascia and we use metzembaum rather than electrical current (Fig. 26.1a, b). The care must also be taken to compress the base of penile shaft, but not to compress penile skin during induction of an artificial erection (Fig. 26.1c). These maneuvers are very important to avoid postoperative skin ischemia. Although some authors insist

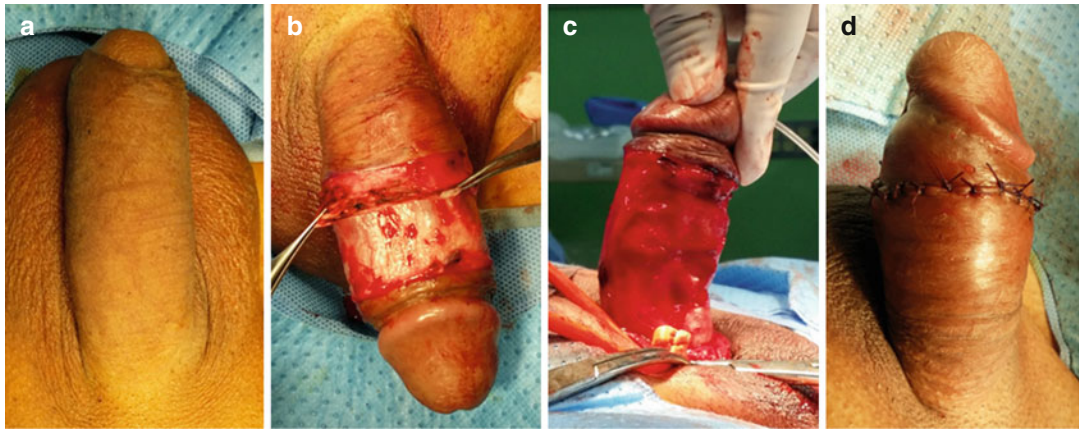

Fig. 26.1 Skin incision and dissection to penile base. (**a**) Uncircumcised status. (**b**) Incision of skin and dartos fascia. (**c**) Compression of penile base for artificial erection test. (**d**) Circumcision and skin closure

that circumcision is unnecessary in uncircumcised men with no obvious sign of phimosis, we usually perform circumcision during reconstructive surgery to reduce the risk of paraphimosis, lymphedema, and wound complications (Fig. 26.1a, d).

Artificial Erection Test

An artificial erection is made by an injection of normal saline into the corpus cavernosum by use of a 21-gauze scalp vein needle after compression of penile base in order to determine the point of maximal curvature and the degree of curvature (Fig. 26.1c). And then mark the area of greatest curvature or narrowing. Instead, we may induce penile erection with intracavernous injection of vasodilators, such as prostaglandin E1 or trimix (papaverine, phentolamine, and prostaglandin E1). We prefer to use former method because it ensures maximal erection, whereas the pharmacologic erection may induce suboptimal erection, resulting in underestimation of the actual penile curvature.

Dissection of Neurovascular Bundle or Urethra

There are two approaches to dissect neurovascular bundle. It is our preference to make a pair of longitudinal incision on Buck's fascia on the lateral aspect of penile shaft to dissect neurovascular bundle. To minimize injury to neurovascular bundle, the incisions are carried out to the 3 and 9 o'clock position just lateral to the corpus spongiosum and dissect into medical side (lateral to medical approach) (Fig. 26.2a, b). Because we frequently encounter adhesion between plaque and overlying neurovascular bundle, the dissection should be begun over normal tissue. Alternatively, neurovascular bundle can be dissected from midline to lateral direction by harvesting deep dorsal vein. However, this approach sometimes does not offer lateral exposure, which is important for the correction of hourglass deformity or severe lateral indentation. To prevent the potential pressure or crush injuries to the dorsal nerve or arteries, we gently retract dorsal neurovascular bundle by use of a 6-mm diameter silastic drain without undue stretching or distraction. We prefer to use sharp and meticulous dissection with metzembaum rather than the use of electrocautery (Fig. 26.2c). For ventral approach, the corpus spongiosum is dissected off of the corpus cavernosum in a similar manner (Fig. 26.2d).

Correction of Penile Curvature

Tunical Shortening Procedures

Nesbit procedure comprises ellipsoidal excision of normal tunica albuginea on the convex side of the penis and the closure of tunical defect. The

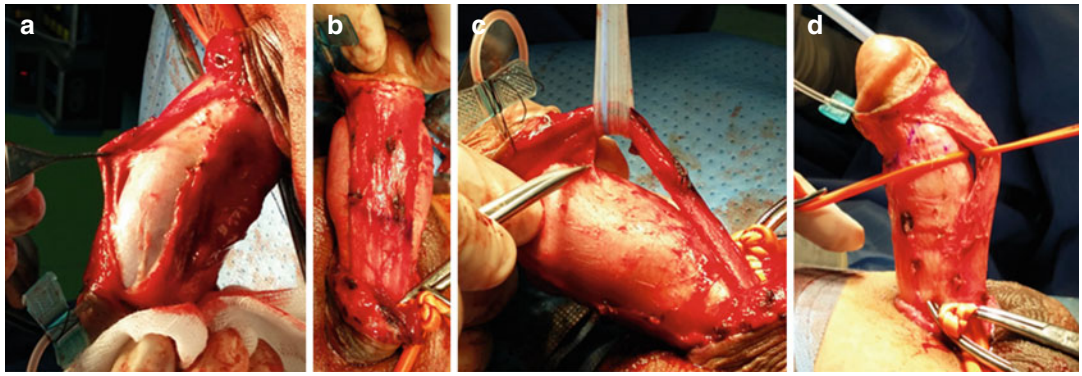

Fig. 26.2 Dissection of neurovascular bundle (**a–c**) or urethra (**d**)

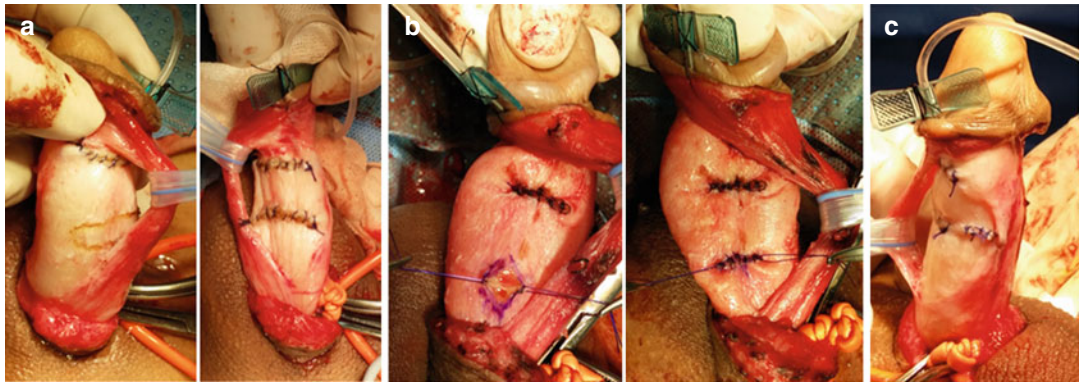

Fig. 26.3 Tunical shortening procedures. (**a**) Nesbit procedure. (**b**) Yachia procedure. (**c**) Artificial erection tests after completion of plication

point of maximal curvature is marked on the opposite side of the plaque after artificial penile erection. A single or multiple 5–10-mm transverse ellipses with different heights (longitudinal diameter) may be excised depending on the degree of curvature. It is preferable to remove multiple small ellipses rather than excising a large wedge to avoid a hinge-effect or dog-ear deformity. The tunical defect is then closed with running 2-0 Vicryl (polyglactin 910) or 3-0 PDS (polydioxanone) suture (Fig. 26.3a). This method provides good tensile strength to tunica albuginea and we can expect good long-term outcomes. A modification of Nesbit procedure is Yachia technique that avoids excision of tunical albuginea, but utilizes a longitudinal incision on tunica albuginea on the convex side. The vertical incision is then closed horizontally with interrupted 3-0 PDS suture. Similar to Nesbit procedure, multiple vertical incisions can be made based on the degree of penile curvature (Fig. 26.3b). For Nesbit and Yachia procedure, we do not use nonabsorbable suture material. Instead, we use absorbable suture materials, such as Vicryl or PDS. In these days, we use PDS suture rather than Vicryl, because it slowly absorbs and provides extended wound support up to 6 weeks.

Penile plication is minimally invasive procedure that does not require dissection of neurovascular bundle or urethra and also avoids the excision or incision of tunica albuginea. The tunica albuginea is merely plicated at the contralateral side of the plaque by use of nonabsorbable suture materials. Plication sutures can be placed in the space between the dorsal vein and arteries for men with ventral curvature or sutures are placed 2 mm lateral to the both sides of corpus

spongiosum in case of dorsal curvature. Even though buried knot technique has been introduced, the palpable knots with or without penile pain from the use of permanent suture may be problematic.

An artificial erection should be induced to confirm whether adequate penile straightening has occurred (Fig. 26.3c). If there is significant residual curvature, additional tunical incision/excision or plication procedures are needed. The placement of Allis clamp on the tunica albuginea may be helpful to decide the site and extent of tunical incision to achieve straightening of penis. Among the tunical shortening procedures, the authors prefer to use Yachia or Nesbit technique, because these procedures reliably provide long-term tensile strength.

Tunical Lengthening Procedures

As we described above, extensive plaque excision may induce high rate of postoperative ED. Therefore, minimal plaque excision should be considered plaque that causes severe indentation or has extensive calcification. In the case of dorsal curvature, Buck's fascia is opened as described above and neurovascular bundle was carefully dissected over Peyronie's plaque. A modified H- or double Y-incision is made in the midline of the plaque to create rectangular tunical defect. Occasionally, more than one tunical incision may be required to correct complex penile deformity. The careful dissection of plaque or tunica albuginea from underlying erectile tissue is critical to reduce the risk of postoperative erectile dysfunction. In addition, we have to keep in mind that the dissection should allow proper correction of deformity in both girth and length. The size of tunical defect is measured when the penis was completely straightened longitudinally and transversely. A variety of graft materials, including autologous graft, allograft, and xenograft, can be used to cover tunical defect. If commercially available allografts or xenografts are used, the size of grafts should be measured after rehydration. The tunical defect is covered with a graft by using a water-tight running 4-0 PDS suture.

Saphenous vein is one of the most frequently used autologous grafts, and it is our preference to use saphenous vein due to relatively ease of harvesting, good compliance and elasticity, and large surface area [25]. Vein graft material may be obtained from the distal or proximal saphenous vein. The authors usually use proximal saphenous vein, because its relatively good diameter makes us possible to cover wide tunical defect. Three or four centimeters of incisions are made near the medical portion of the knee and femoral area to isolate a segment of the proximal saphenous vein. By using an occlusion catheter for stripping saphenous vein (stripping technique), we can harvest more than 15 cm of vein with two small incisions (Fig. 26.4a, b). Divide the harvested vein into three or four segments and open the lumen of vein longitudinally and assemble with continuous running 5-0 Prolene (polypropylene) suture depending on the size of tunical defects. The knots should be located at luminal side of vessels to avoid pain or discomfort associated with palpable knot (Fig. 26.4c). The saphenous patch graft is positioned endothelial side down and is sutured to the defect with continuous 4-0 PDS suture (Fig. 26.4d) [26]. Close lower extremity wound with subcuticular 4-0 polyglycolic acid. And upper part of the lower extremity should be compressed with elastic bandage to avoid hemorrhage from the small branches of proximal saphenous vein. We believe that saphenous vein grafting by use of a "stripping technique" is a relatively simple procedure and is easy to perform.

Again artificial erection is created to ensure leakage from grafting area and to determine residual curvature. If there is substantial curvature requiring correction ($\geq 20°$), we usually make small longitudinal incision and close transversely (Yachia procedure) to correct residual curvature.

Wound Closure

Buck's fascia is re-approximated with a running 4-0 Vicryl suture ensuring anatomic repositioning of neurovascular bundle as well as vascular support for the graft and creating tamponade to prevent bleeding and hematoma formation. And then,

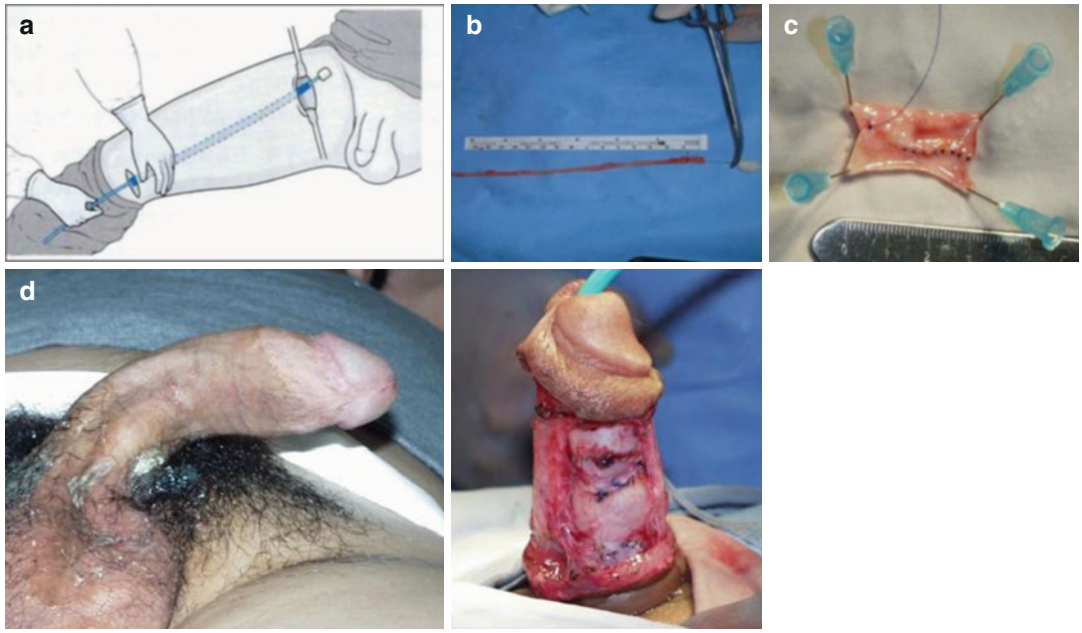

Fig. 26.4 Tunical lengthening procedures with a saphenous vein graft by use of a "stripping technique" (Used with permission from Suh [26]). (**a**) A cartoon for 'stripping technique'. (**b**, **c**) Harvested proximal saphenous vein and design for grafting. (**d**) Straightening of penis after completion of saphenous vein grafting

dartos fascia and skin are closed layer by layer with interrupted 4-0 Vicryl suture (Fig. 26.5a–c).

Wound Dressing and Postoperative Care

After completion of skin closure, the Vaseline gauze is applied over suture line and then the entire penis was wrapped with a gauze pad. And finally, the penis is gently compressed with a Coban™ elastic band (3 M, St. Paul, MN, USA) (Fig. 26.5d). Excessive compression should be avoided to reduce ischemia, and the color of glans should be checked at the recovery room and then at regular intervals. We do not use a drain and urethral catheter is inserted at the end of the operation and the catheter is removed the first postoperative day. If the patients suffer from significant pain related with erection, this can be controlled with diazepam and amyl nitrite. However, we do not routinely prescribe these drugs, because the penile pain usually disappears immediately and may be controlled by analgesics. Sexual intercourse or masturbation should be avoided for 6 weeks after operation.

Postoperative Rehabilitation

Postoperative rehabilitation is also important for the successful surgical outcomes. It may reduce penile shortening and be helpful to preserve erectile function postoperatively. We recommend penile stretch and massage starting at 3 or 4 weeks postoperatively to prevent penile shortening and ensure penile straightening. The patients are advised to grasp glans penis and gently pull as well as massage graft area twice a day for 4 weeks. The application of external penile traction device is also known to reduce penile shortening. In a retrospective study of 111 patients comparing efficacy of the use of traction therapy after plication or partial excision and grafting surgery for PD, traction therapy, which was given for 2–6 h per day for 3 months starting 3–4 weeks postoperatively, significantly increased postoperative penile length compared to preoperative status, on the order of 0.8–1.5 cm, without subjectively perceived loss of

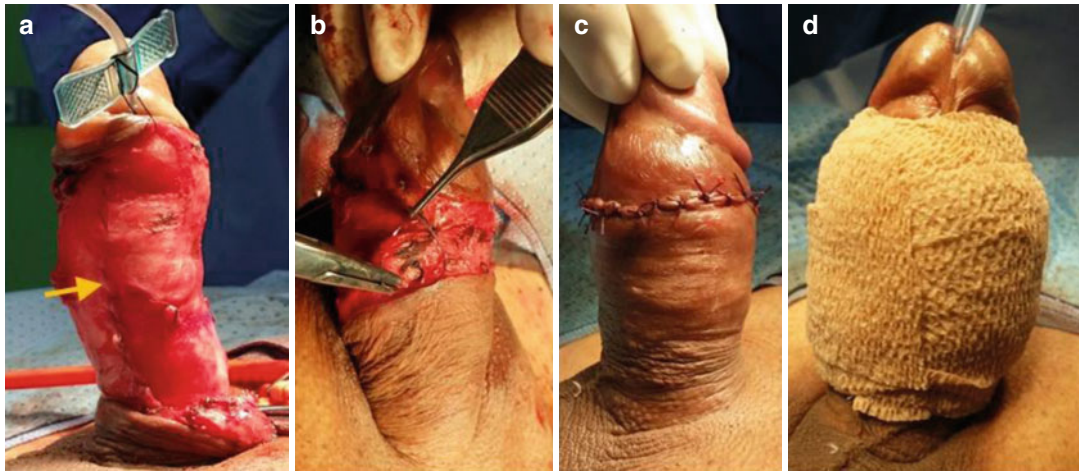

Fig. 26.5 Wound closure and dressing. Closure of Buck's fascia (**a**), dartos fascia (**b**), and skin (**c**) and gentle compression with elastic band (**d**)

penile length [27]. Unfortunately, this device is as yet not available in South Korea. Some authors prefer to use nightly PDE-5 inhibitors to enhance penile blood flow in postoperative period and to encourage nourishment of the graft thereby reducing postoperative ED [20]. We do not routinely use PDE-5 inhibitors, but administer these drugs in selected cases whose baseline penile rigidity was suboptimal.

Conclusion

The current medical treatment modalities have failed to alter the progression of PD, and surgical intervention is the only efficacious treatment for this condition. Reconstructive surgery for PD should be individualized and tailed to the severity and complexity of penile deformity, penile length, and preoperative erectile function. It is imperative to set appropriate expectation for the patients and to obtain preoperative consent that includes possibility of persistent or recurrent curvature, penile shortening, decrease in penile rigidity, and reduction in penile sensation. In men with normal erectile function or ED that responds to pharmacotherapy, either tunical shortening or lengthening procedures may be employed. Penile prosthesis implantation is the treatment of choice in men with PD and ED refractory to medical treatment. The recent advancements and refinement of surgical technique along with proper selection of patients make reconstructive surgery a viable treatment option for PD patients.

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Penile Reconstruction of Amputated Penis

27

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Introduction

Over the years, many different techniques have been described for penile reconstruction in order to achieve normal form and function according to the individual patient requirements. Additionally, in the choice of appropriate surgical procedure, it is crucial to carefully assess the patients' physiognomic wishes as well as psychological aspects in order to achieve the optimal therapeutic goal for both partial and total penile defects.

The advances in plastic surgery, especially in reconstructive microsurgery, give us the possibilities to obtain the expected goals. Recent developments of different flap techniques nowadays offer the optimal result with minimal donor site morbidity.

The absence or loss of the penis includes severe social and psychological implications, thus addressing a wide range of issues to take into consideration in penile reconstruction. Conditions leading to serious penile insufficiency include:

- Congenital conditions (disorders of sexual development):
  - Aphallia or penile agenesis
  - Idiopathic micropenis
  - 46,XY disorder of sexual development
  - Exstrophy
  - Cloacal exstrophy
- Genital trauma:
  - Injury
  - Surgery
- Penile amputation
- Female-to-male gender dysphoria

All cases constitute an indication for phalloplasty with the goal of creating or reconstructing a functioning and aesthetic penis. Therefore, the surgeon's ideal objective in performing penile reconstruction should focus on a single-stage surgical procedure achieving a customary appearing phallus with erogenous and tactile sensation allowing the patient to have sexual intercourse. In addition, voiding while standing and providing a normal scrotum should be targeted.

History

Total penile reconstruction was first performed 1936 by the Russian surgeon Nikolai Borgoras using a tubed pedicled flap [1, 2]. Ten years later, in 1946, Maxwell Maltz and Sir Harold Gillies reconstructed a phallus with a urethra made from

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a tubed abdominal flap using a tube-within-a-tube technique adding rib cartilage as a stiffener and established a benchmark for the next 30 years [3–5]. The history of penile reconstruction developed simultaneously with the history of plastic surgery as microsurgery allowed the use of a broader range of well-vascularized tissue such as the radial forearm flap, free fibular flap, or the anterolateral thigh flap [6]. In 1984, T. S. Chang and W. Y. Hwang carried out the first one-stage penile reconstruction using the radial forearm flap with the tube-within-a-tube technique as well as autologous cartilage and nerve anastomosis for erectile and sensate function. In 1988 Biemer described an alternative way to roll the flap not only to achieve a tube-within-a-tube flap but also excess length of the neo-urethra [7].

However, over the past centuries several different pedicled flap techniques have been described. The *Stanford bipedicled infraumbilical skin flap* is raised on an inferior and superior pedicle fed by the superficial external pudendal vessels. It tubed an infraumbilical abdominal skin flap outside-in and was wrapped in a skin graft [8–10]. In a similar fashion Snyder described a *single pedicled infraumbilical flap* in which a prelaminated skin-lined conduit was used for urethra reconstruction [11, 12]. Song raised an infraumbilical midline pedicled flap on the superficial epigastric vessels, reconstructing the urethra from a distal extension of the abdominal flap or from a local scrotal flap [13]. Hester performed phalloplasty using a *single subcutaneous pedicled infraumbilical flap* fed from the superficial inferior epigastric artery [14]. Bouman added to this technique the incorporation of the superficial pudendal vessels [15]. The *pedicled groin flaps* were first described for penile reconstruction by Puckett and Montie [16] and Exner [17, 18] used a rectus abdominis muscle flap covering a rigidity prosthesis wrapping bilateral pedicled groin flaps around. *Pedicled thigh flaps* were first mentioned by Morales et al. [19] and Julian et al. [20] as single tubed skin flaps and later by Kaplan and Wesser as superior pedicled thigh flaps for sensate penile reconstruction [21]. In 1972 Orticochea described the *pedicled myocutaneous gracilis flap* for phalloplasty, further developed by Persky enhancing penile bulk by using bilateral myocutaneous gracilis flaps [22]. Also, the rectus abdominis myocutaneous flap has been reported by several authors for penile reconstruction. In 1997 Santanelli and Scuderi reconstructed a neophallus using a *neurovascular tensor fascia lata island flap* with minimal donor-site morbidity [23]. This could also be raised as a pre-expanded flap enhancing not only blood circulation but also primary closure of the donor site. At last, Durfee and Rowland described a method of creating a neophallus known today as *metaidoioplasty* by androgen-enhanced clitoral enlargement in female transsexuals [24].

Patient Assessment

Reconstruction of penile defects always requires a multidisciplinary approach not only involving a urologist and reconstructive plastic surgeon but also a psychiatrist for a psychological support before, during, and after reconstruction. This is essential due to the fact that penile defects most often lead to mental stress, culminating in depression or even suicide.

From the reconstructive point of view, the assessment of missing structures is ranked first. Subsequently, the anatomical, functional, and aesthetic requirements must be determined. The anatomical aspect covers the extent of tissue loss, whether a partial or total penile defect is found and whether urethral reconstruction is necessary. Also, the quality of vascular and neural supply must be evaluated, whether the patient has protective or tactile sensation and if the ilioinguinal or pudendal nerves are intact for future erogenous sensation after phalloplasty. As for the functional requirements, the patient's sexual history and desired goals must be considered, and therefore voiding while standing and allowance of sexual intercourse must be obtained. Lastly, the aesthetic aspect and premorbid length of the penis must be taken into account creating an aesthetically pleasing phallus with a normal scrotum.

Reconstruction of Urethral Defects

Urethral reconstruction from a plastic surgeon's point of view is rare and would only be taken into consideration in penile reconstruction according to the patients' reconstructive requirements. Patients with urethral defects resulting from malignancy in most cases don't qualify for reconstruction due to age and comorbidities, as well as patients where urinary diversion will be performed through the medium of an ileal conduit.

Indications for reconstruction result primarily from urethral deficiencies such as strictures. In these cases the urethra can be exposed either via a T-shaped incision on the ventral aspect of the penis, a circumferential incision approximately 5 mm below the glans, or a midline perineal incision exposing the bulbar urethra. In order to prevent strictures, the reconstruction must be stented by a urethral catheter or the urine diverted through a suprapubic catheter.

Defects measuring 2–3 cm can be anastomosed in an interrupted manner after mobilization from the corporal cavernosa [25]. Should a tension-free anastomosis be impossible, anastomosis of the one side with augmentation onlay of the opposite side is carried out. Buccal mucosa or skin flap on a well-vascularized bed can be used as an onlay filling the defect [26, 27].

For reconstruction of circumferential defects, a pedicled skin flap based on the prepuce, the penile shaft, or the scrotum may be used. Our experience shows, that all reconstructive options are solely performed by urologists. Only total urethral reconstruction using a free flap is performed in cooperation between a plastic surgeon and a urologist.

Reconstruction of Partial Penile Defects

Burns, trauma, or surgical excision can result in isolated skin loss, where split-thickness skin grafting offers sufficient coverage, especially combined with vacuum-assisted dressing (VAC®, Kinetic Concepts Inc., San Antonio, TX). Alternatively, for full-thickness or deep partial-thickness skin defects, INTEGRA®, a two-layer dermal regeneration template, can be applied. The inner layer is constructed of a complex matrix of fibers covered by a silicone layer. After removing the outer silicone sheet after 3 weeks, the well-vascularized bed is covered by a split-thickness skin graft. Skin deficiencies can also be covered by scrotal skin flaps based on the anterior or posterior scrotal arteries [28].

As an alternative for deep penile defects, regional (i.e., pedicled anterolateral thigh flap) and free flap transfer (i.e., free radialis flap) have become versatile tools for reconstruction (see presented cases).

In cases of partial penectomy with preservation of penile length of 2–3 cm, augmentation in terms of a V-Y plasty from the abdominal wall or severing the penile ligament can be sufficient, as long as urinating in a standing position is obtained.

In rare cases of patients with isolated erectile dysfunction not amenable to prosthesis reconstruction, a prefabricated cadaveric bone flap based on the descending branch of the lateral circumflex femoral artery can achieve restoration of sexual function. As a pedicled flap this is then implanted within the corpora cavernosa [29].

Reconstruction of Total Penile Defects

There is a wide spectrum of total penile defects requiring reconstruction ranging from trauma, over congenital conditions (aphallia or penile agenesis, idiopathic micropenis, 46,XY, cloacal exstrophy) and transsexualism, to malignancy. Penile amputations are seen in cases of autoerotic accidents, psychological disorders [30], or domestic violence [31].

In situations of an intact amputated penis with sharp wound borders and adequate tissue quality, microsurgical replantation seems to be the best

reconstructive option. Occasionally, other techniques with recruitment of sufficient tissue are required for optimal outcomes. Many regional options with transferring fasciocutaneous tissue from the groin or abdominal area and pedicled myocutaneous flaps such as musculus rectus abdominis, gracilis, or tensor fascia lata flaps have been described in the past [16].

However, in order to reach optimal functional and aesthetic results, microsurgical free-tissue transfer with nerve coaptation has become the gold standard in penile reconstruction.

The anatomical requirement for an optimal microvascular reconstruction is a free flap, which is sensate, hairless, and long pedicled and has an adequate thin skin quality to allow the creation of a tube with incorporation of the neo-urethra. The functional aspect of the reconstructed phallus is to void while standing and enable sexual intercourse. Furthermore, an aesthetically pleasing phallus with a normal-looking scrotum should be created.

The radial forearm flap meets these conditions and is currently most commonly performed for total penile reconstruction worldwide.

The existence of many other techniques for penile reconstruction is evidence that none is considered as ideal.

Radial Forearm Flap

The free radial forearm flap was first described by Chang and Hwang for total penile reconstruction in 1984 [6].

Nowadays many reconstructive surgeons describe that technique with its advantages of raising a flap with very thin tissue and a long pedicle in a constant anatomical area as state of the art for penile reconstruction [32].

The anatomical distance between the donor and recipient site makes it possible to operate simultaneously in a two-team approach reducing significantly operating time.

Preoperatively the Allen test is essential to make sure that the perfusion of the hand will not be compromised when sacrificing the radial vascular system. The flap is usually raised from the nondominant forearm. In many cases it is an interdisciplinary approach with a urologist preparing the genital region with preparation of the urethral stump while the plastic surgeon is raising the flap.

In a two-stage approach prelamination of the neo-urethra can be performed by implantation of a stent covered most often with a split-thickness skin graft into the radial forearm skin a few weeks prior to free flap transfer [33].

Alternatively the ulnar skin can be used to form a “tube-within-a-tube” free flap in a one-stage procedure [34, 35]. During flap harvesting the medial and lateral antebrachial nerves are identified and preserved for anastomosis, one to the ilioinguinal nerve for protective sensation and the other to the dorsal penile or dorsal clitoral nerve for erogenous sensation. Depending on the availability of recipient vessels in the genital area, most often the femoral artery and great saphenous vein or the inferior epigastric vessels are used for microsurgical connection. To provide extra rigidity in very rare cases, an osteocutaneous flap can be harvested with bone from the radius. Prophylactic plating may be used to decrease the incidence of subsequent radius fractures [36].

After protective sensation of the penile tip has developed (about 12 months postoperatively), an erectile prosthesis and testicular implants can be placed to allow sexual intercourse. The forearm donor site is covered with split- or full-thickness skin grafts from the groin. Postoperative urinary diversion is essential to protect the urethral anastomosis. Tattooing of the glans can be performed 2–3 months later to improve the aesthetic result [37]. Studies have shown a significant high incidence of urinary complications (41 %) such as urethrocutaneous fistula or urinary stricture following penile reconstruction [34, 35], although

most cases of fistulas and strictures can be treated conservatively.

Also, other authors have described the radial forearm flap using non-microsurgical techniques for total penile reconstruction [38].

Free Fibular Flap

Sadove et al. first described the free osteocutaneous fibular flap for total penile reconstruction in 1992 [39]. The advantages of this technique are its hidden donor site, long pedicle, and intrinsic rigidity with increased availability of bone, which makes a penile implant for sexual intercourse unnecessary. However, disadvantages include decreased sensation, increased urethral complications, and a permanently erect penis that may cause distress and social embarrassment [37]. Despite decreased sensation, better sexual intercourse has been reported by patients who were reconstructed by a free fibular flap compared with those who underwent free radial forearm flap transfer [40].

Overall, this technique is preferred by some patients who dismiss the radial forearm donor-site morbidity since it has become a stigma for a certain patient collective during the last decades.

Anterolateral Thigh Flap

In the past years the pedicled anterolateral thigh flap (ALT) [41–43] and the free ALT flap [44] have become more popular for total and in some cases for partial penile reconstruction. The advantages of this flap are its excellent aesthetic outcome with its concealed donor site (in comparison to previously used pedicled flaps or the radial forearm flap) and its possibility of sensation due to coaptation of the lateral femoral cutaneous nerve to the pudendal or dorsal penile/clitoral nerve. Penile and testicular implants can also easily be placed.

Reconstructive Alternatives

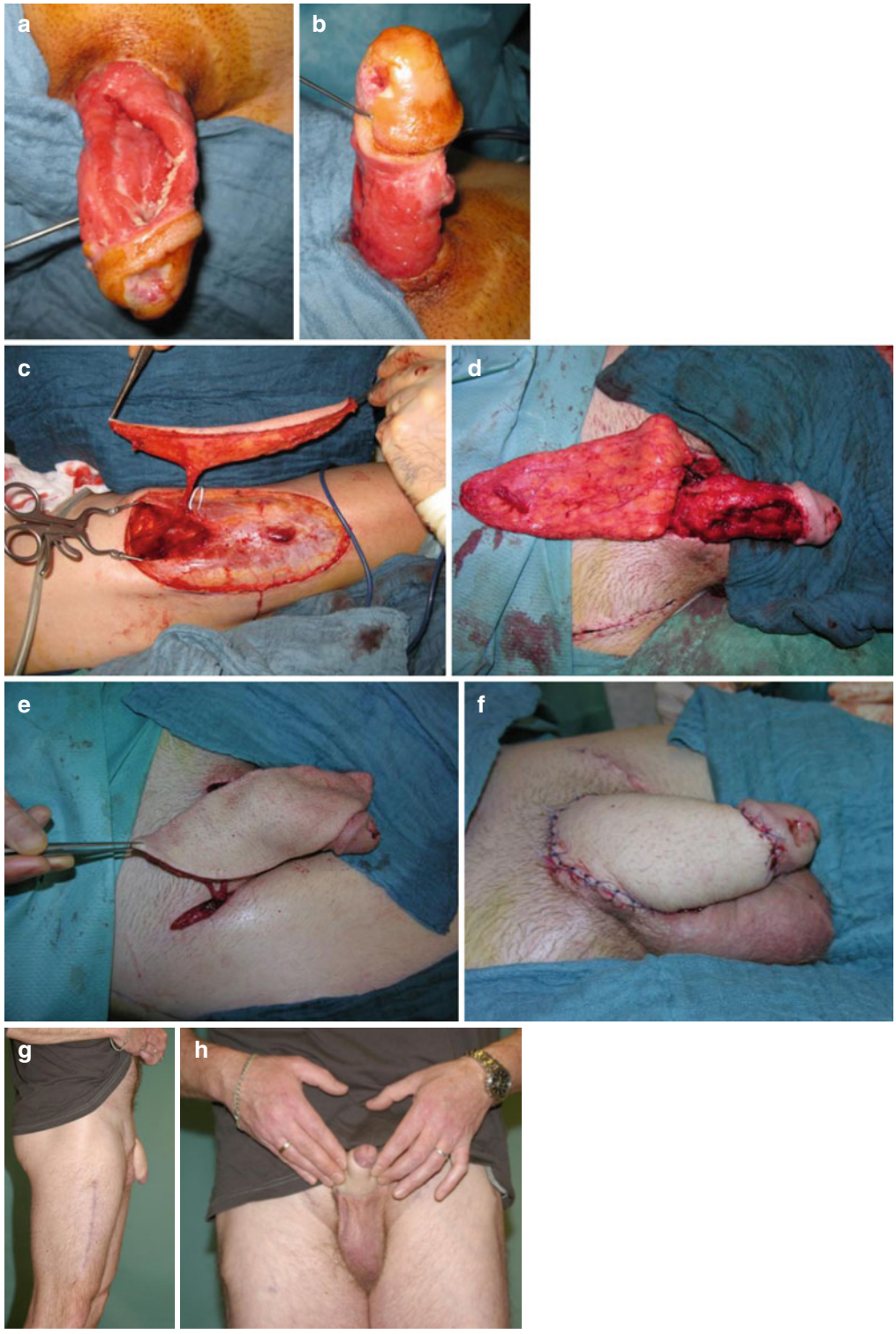
Since the radial forearm scar has become a stigma to a certain patient group, efforts have been made to develop other techniques to improve the donor-site morbidity. In 2005 the pedicled suprapubic abdominal wall flap was described for penile reconstruction [45]. Although advantages to this technique are the acceptable aesthetic result and the ability to achieve sexual intercourse with implantation of a prosthesis, a major limitation is the high rate of urinary complications (75 %) [45].

A few years later, in 2006, the free musculocutaneous latissimus dorsi flap [46] and in 2009 the free thoracodorsal artery perforator flap [47] have been described for penile reconstruction. Advantages are its concealed donor site and the availability of a big amount of sufficient tissue.

Finally, in 2006, penile allotransplantation has been described in an isolated case report [48]. Without physical postoperative complications the transplanted penis had to be cut off at day 14 due to psychological issues.

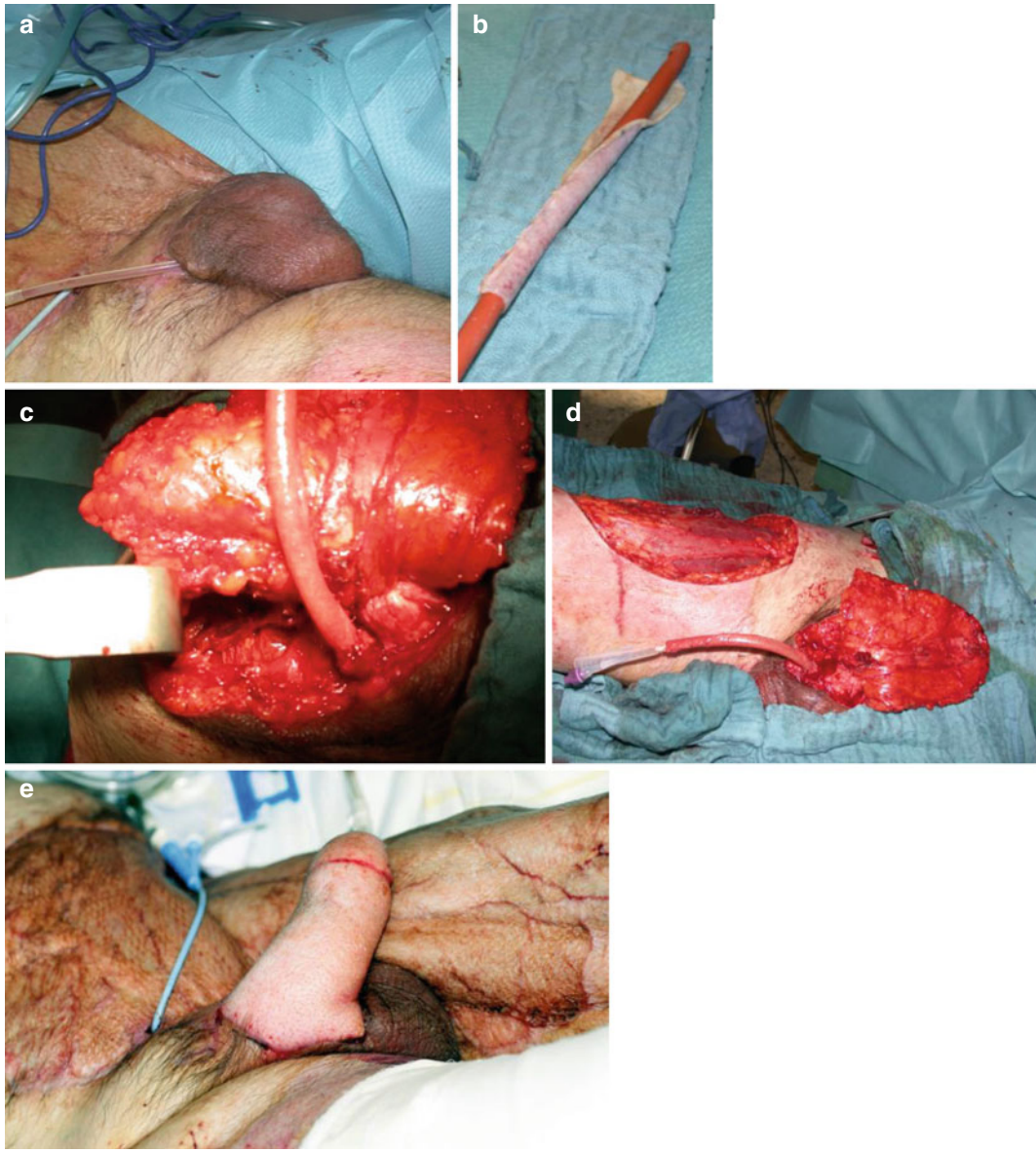
In conclusion, penile reconstruction still remains a very complex procedure without the ideal solution. Recent research developments are very promising but far away from clinical application. Therefore, taking all methods of reconstruction into consideration, we have to keep in mind the main reconstructive goal, that only a functional and aesthetic phallus with the ability to void standing and to achieve sexual function will be accepted by patients.

Case Example 27.1 A 46-year-old patient with status post priapism suffering from severe *partial penile defects* with circular skin and partial corpus cavernosum necrosis. After initial evaluation with assessment of missing structures, single-stage reconstruction was performed by a *pedicled anterolateral thigh flap* (ALT flap).



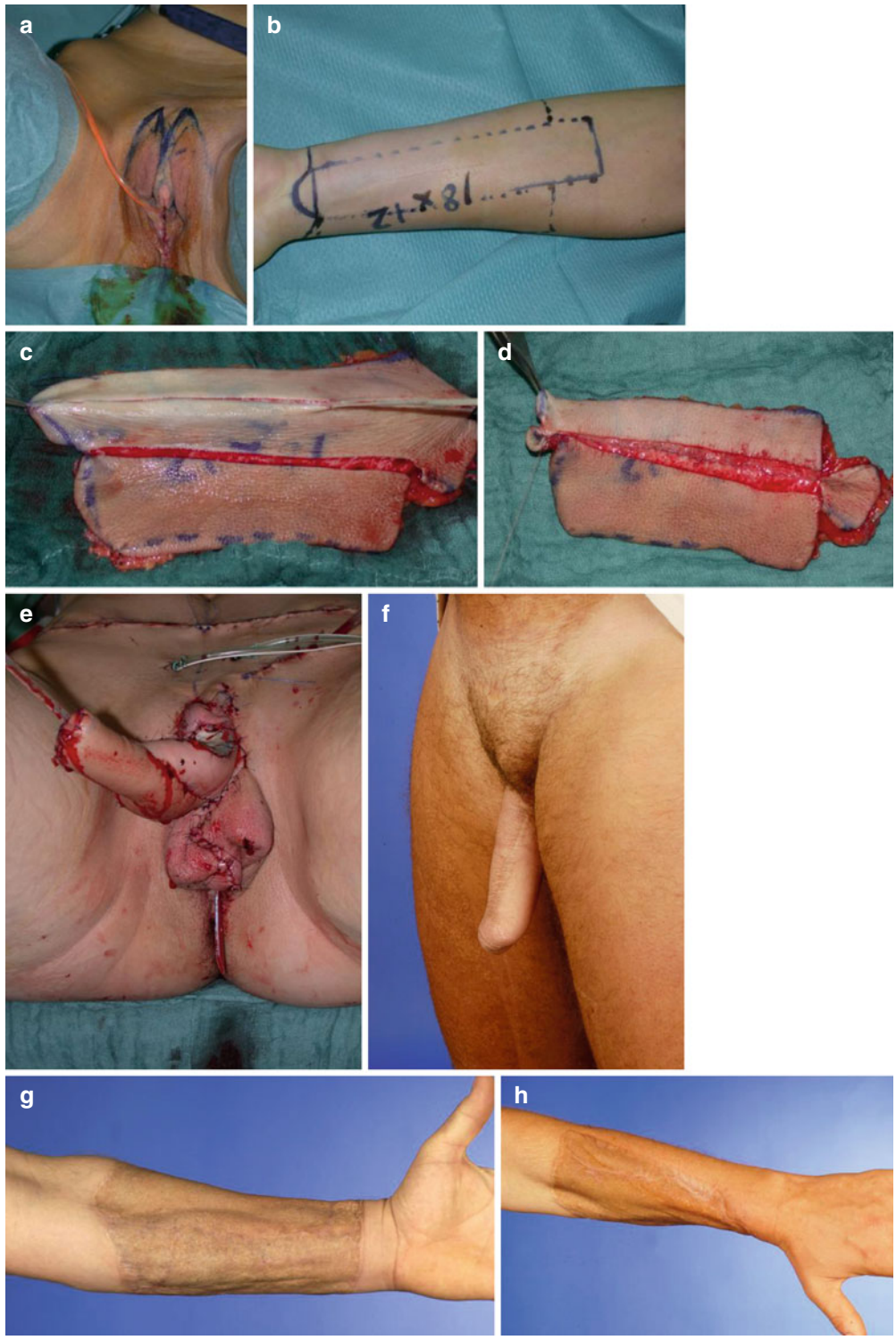
(**a**) Penile defects with partial skin and corpus cavernosum necrosis. (**b**) Dissected pedicled ALT flap. (**d**, **e**) Transposed pedicled ALT flap. (**f**) Direct postoperative view. (**g**, **h**) Seven months after penile reconstruction

Case Example 27.2 A 51-year-old patient with *total penis amputation* after severe burn injury of lower trunk, genital region, and left thigh. Single-approach total penile reconstruction was performed by a pedicled anterolateral thigh flap (*ALT flap*).



(**a**) Total penile defect. (**b**) Split-thickness skin graft for urethra reconstruction. (**c**, **d**) Pedicled ALT flap. (**e**) 10 days postoperatively

Case Example 27.3 Single-stage penis reconstruction in female-to-male gender dysphoria using a free radialis flap (RFF).



(**a**) Preoperative view. (**b**) Planning the free RFF. (**c**, **d**) Skin-lined neo-urethra, tube-within-a-tube. (**e**) Intraoperative view. (**f**) One-year follow-up. (**g**–**h**) Donor-site morbidity after free RFF one year postoperatively

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Part VI

Pediatric Surgery

Pediatric Perspective: Inconspicuous Penis

28

Sang Don Lee

Introduction

An inconspicuous penis refers to a group of conditions that the penis appears to be small but the shaft can be normal or abnormal in size. It could be a source of constant concern for both parents and children. The term "inconspicuous penis" was first used in the literature by Bergeson et al. [1] in 1993. This could be secondary to short penile shaft often termed as micropenis. But more commonly, this inconspicuous appearance is secondary to other causes ranging from congenital conditions such as penoscrotal webbing or megaprepuce, developmental conditions like prepubic adiposity that overhangs the penis, and iatrogenic causes like trapped penis after adhesions secondary to circumcision [2]. However up to now there is still confusion by defining of inconspicuous penis in the literature review and in the clinical practice [3–15].

The penis is inconspicuous if it is absent (penile agenesis), diminutive (epispadias, hypospadias, chordee), a micropenis (hypothalamic, pituitary, or testicular origin), or concealed [12]. The inconspicuous penis has a diverse etiology, including deficient penile skin, laxity of attachment at the penile base, tethering of the penile skin forward on the cavernosa by dysgenetic dartos tissue, scrotal webbing, excessive suprapubic fat, and secondary causes such as cicatricial scar after circumcision and a large hernia or hydrocele [5–7, 16–18]. Based on the literature review, inconspicuous penis is a more broad conception and includes webbed penis, concealed penis, buried penis, hidden penis, trapped penis, and micropenis. Concealed penis, buried penis, hidden penis, trapped penis, and webbed penis are normal in size, but micropenis is abnormally small.

The prompt recognition of abnormal genital development in the child is very important because the small or inconspicuous penis is maybe the earliest recognizable clinical manifestation of hypothalamic-pituitary-gonadal axis hormonal deficiencies and is also one of the features of several genetic syndromes such as Down syndrome, Noonan syndrome, and Williams syndrome. Inconspicuous penis causes often psychologically negative effects, low self-esteem, to the child or family [19–22]. The psychological pressure on children and their parents can be enormous over time, and counseling may well have an important role in the correction of inconspicuous penis. Therefore, the early diagnosis of abnormalities of penis is important both medically and psychologically, and the exact assessment of this is also important in the diagnosis and management of penile problems.

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Normal Development of Penis

As with many genital disorders, an understanding of the relevant embryology allows a better understanding of the condition itself. Normal sexual differentiation begins on the seventh week of gestation when the fetus contains both the male and female genital ducts. Beginning at 8 weeks of gestation, maternal human chorionic gonadotropins (hCG) from the placenta begin to stimulate testosterone production from the fetal Leydig cells [23]. Fetal testosterone levels in males are elevated between weeks 8 and 24 of gestation, with peak levels occurring between weeks 14 and 16, while postnatal male testosterone levels increase from birth to a peak at 1–3 months and then decrease to prepubertal levels by 4–6 months [24]. Under the influence of dihydrotestosterone, penile differentiation occurs. The genital tubercle differentiates into the glans penis, the genital folds become the shaft of the penis, and the genital swellings migrate to the midline to become the scrotum. Penile differentiation is complete by 12 weeks of gestation [23] By the fifteenth week, the regulation of testosterone secretion is taken over by gonadotropins from the fetal pituitary, which is regulated by the fetal hypothalamus to form the hypothalamic-pituitary-gonadal axis. During the second and third trimester, growth of the penis is accomplished through fetal testosterones, which are produced under stimulation by fetal pituitary gonadotropin. There is a marked increase in penile size over that time period, with the penis growing almost 20 mm from 16 to 38 weeks [25, 26]. The highest penile growth velocity is associated with the increased levels of testosterone during the 0–3-month period after birth. Thus the postnatal surge in reproductive hormones appears to be important for genital growth [27]. Without satisfactory hypothalamic or pituitary function, inadequate penile growth will occur despite a normally shaped penis. Similarly, a primary testicular disorder that causes insufficient testosterone production near the end of gestation also can result in minimal penile growth [20].

Measurement and Normal Range of Penile Length

Measurement of Penile Length

The accurate measurement of penile length is very important in children with abnormal genital development (e.g., micropenis, buried penis, or hypospadias) and is specifically performed to detect underlying severe endocrinologic and chromosomal disorders, such as Down syndrome, Noonan syndrome, and Williams syndrome [19–22]. Micropenis refers to an abnormally small, normally structured penis with a stretched penile length of less than 2.5 standard deviations (SD) below the mean for age or stage of sexual development [28]. Micropenis can be considered a clinical sign of a larger syndrome or an independent anomaly [20]. Therefore it is also important to make a distinction between micropenis and normal-sized other inconspicuous penis. However, up to now there are still scarce data on the penile length measurements in children, especially in a wide range of age groups.

As for the various anthropometric measurements like weight and height, penile length is known to have ethnic variation, and thus there is a need to establish penile length data for different ethnicities. To the best of my knowledge, there are a few reports describing the relationship between ethnicity and size of the penis in healthy newborns [29–31]. Phillip et al. [29] found a significant difference in clitoral length, but not in penile length, between babies of Jewish and Bedouin backgrounds in Israel. Recently, in Singapore [30], a study that included a few Indian babies reported a small but significant difference between male newborns from Indian and Chinese origin [31]. Studies of penile length in children have been conducted only rarely, especially in a wide range of age groups. Most studies on penile length have been confined to the neonatal period only [21]. A few recent studies in Indian, Korean, and Turkish populations have recorded penile lengths beyond the neonatal period [32–34]. Therefore it is sometimes very difficult to differentiate between micropenis and small-sized other inconspicuous penis in the clinical practice because of a scarce data on the penile length normograms and ethnic variation.

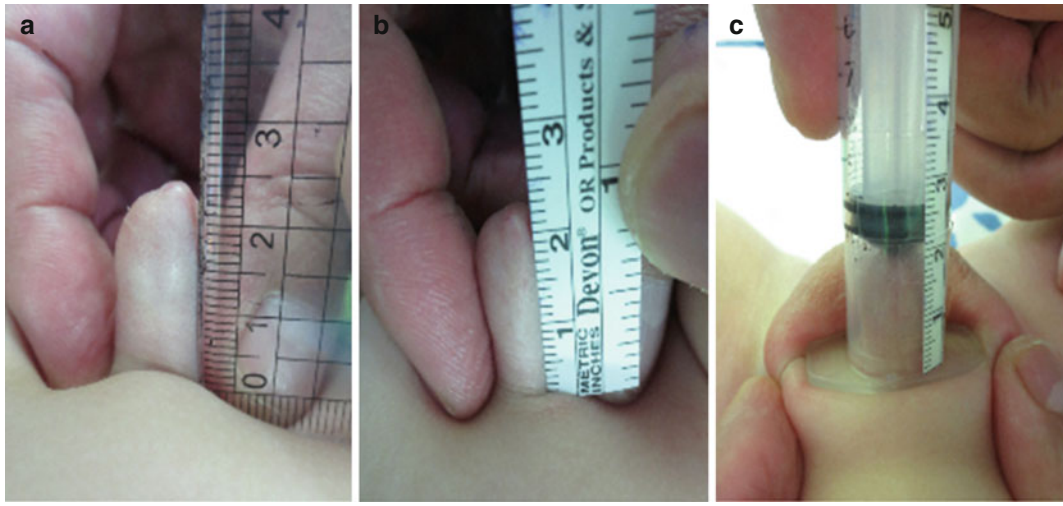

Fig. 28.1 Measurement of stretched penile length (SPL) by a ruler (**a**, **b**) or a 10-ml disposable syringe. (**c**). Penile length should be measured by assessing the SPL from the tip of the glans to the base of the penis at its attachment to the symphysis pubis

Various methods have been introduced to measure penile size. Of the various methods available for measuring penile length, the stretched penile length (SPL) has been widely used in the clinical practice (Fig. 28.1a, b). The SPL was chosen as the measure of penile size, as this has been stated to be the most useful and reproducible method [35]. Penile length should be measured by assessing the SPL from the tip of the glans to the base of the penis at its attachment to the symphysis pubis. With the child laid supine on the examination bed, the foreskin should be fully retracted if possible. The SPL is usually measured with a ruler or calipers by compressing the fat tissue with one end of the ruler through the pubic ramus; the penis is then fully stretched, and the distance to the glans of the stretched penis is measured and recorded. In an obese infant or child, one must be careful to depress the suprapubic fat pad completely to obtain an accurate measurement. However, the SPL method is sometimes insufficient at accurately measuring penile length in children with an inconspicuous penis [32]. In general, full-term newborns must achieve a measurement of less than 2.5 cm, or 1 inch or at least 1.9 cm, to meet the definition of micropenis [20, 36]. Penile length increased slowly but steadily until 4 years of age and then increased rapidly beginning at puberty.

Another option for penile measurement involves the use of a 10-ml disposable syringe [20, 37, 38] (Fig. 28.1c). This method eliminates measurement variability caused by a suprapubic fat pad, but it does not involve stretching of the penis. However this measurement cannot be applied to older children.

Stretched Penile Length in Normal Male Subjects

The stretched penile length in normal male subjects is a little different according to the rapporteur [19, 21, 32–34, 39, 40] because of ethnic variation, genetic heterogeneity, biologic and environmental changes, and different feeding patterns. Besides study population sizes and selection of participants as well as methodological variation may explain differences seen in penile length (Table 28.1). The studies performed on penile length in the newborn period in different populations revealed different normal values of 2.86–3.75 cm [33]. Studies originating from some Asian countries such as East India, Singapore, and Saudi Arabia have had similar results for the newborn stretched penile length, and some studies from Indonesia, Japan, and China have had significantly lower values [33]. By Cheng and Chanoine [31] penile length and

Table 28.1 Mean ± standard deviation (mean—2.5SD) stretched penile length in normal male subjects

Age	Custer and Rau (2009) [39]	Lee et al. (1980) [19]	Camurdan et al. (2007) [33]	Cinaz et al. (2012) [34]	Teckchandani and Bajpai (2014) [21]	Chung et al. (1987) [40]	Lee et al. (2012) [32]
Newborn: 30 weeks	2.5 ± 0.4 (1.5)						
Newborn: 34 weeks	3.0 ± 0.4 (2.0)						
Newborn: term	3.2 ± 0.4 (2.5 ~ 2.4)		3.65 ± 0.27 (2.96)	3.64 ± 0.36 (2.74)		3.3 ± 0.5 (2.3)	
0–3 months	3.9 ± 0.8 (1.9)	2.7 ± 0.5	3.95 ± 0.35 (3.05)	4.44 ± 0.69 (2.72)	4.02 ± 0.49 (2.8)	3.5 ± 0.5 (2.3)	4.4 ± 0.6
3–6 months	3.9 ± 0.8 (1.9)	2.7 ± 0.5	4.26 ± 0.40 (3.24)	4.44 ± 0.69 (2.72)	4.02 ± 0.49 (2.8)	3.5 ± 0.5 (2.3)	4.4 ± 0.6
6–12 months	4.3 ± 0.8 (2.3)	2.7 ± 0.5	4.65 ± 0.47 (3.48)	4.44 ± 0.69 (2.72)	4.02 ± 0.49 (2.8)	3.5 ± 0.5 (2.3)	4.4 ± 0.6
1–2 years	4.7 ± 0.8 (2.6)	2.7 ± 0.5	4.82 ± 0.44 (3.82)	5.42 ± 0.62 (3.87)	4.50 ± 0.53 (3.2)	4.1 ± 0.7 (2.7)	4.8 ± 0.6
2–3 years	5.1 ± 0.9 (2.9)	3.3 ± 0.4	5.15 ± 0.46 (3.98)	5.66 ± 0.73 (3.84)	5.01 ± 0.56 (3.6)	4.4 ± 0.7 (3.0)	5.1 ± 0.6
3–4 years	5.5 ± 0.9 (3.3)	3.3 ± 0.4	5.58 ± 0.47 (4.39)	5.87 ± 0.79 (3.90)	5.52 ± 0.63 (3.9)	4.4 ± 1.0 (2.5)	5.3 ± 0.7
4–5 years	5.7 ± 0.9 (3.5)	3.9 ± 0.9	6.02 ± 0.50 (4.80)	6.33 ± 0.56 (4.93)	5.82 ± 063 (4.2)	4.9 ± 0.9 (3.1)	5.6 ± 0.7
5–6 years	6.0 ± 0.9 (3.8)	3.9 ± 0.9		6.30 ± 0.74 (4.45)	6.11 ± 0.11 (4.6)	5.1 ± 1.0 (3.1)	5.8 ± 0.8
6–7 years	6.1 ± 0.9 (3.9)	4.2 ± 0.8		6.46 ± 0.68 (4.76)	6.31 ± 0.66 (4.7)	5.2 ± 0.8 (3.5)	6.0 ± 0.6
7–8 years	6.2 ± 0.9 (3.7)	4.2 ± 0.8		6.63 ± 0.68 (4.93)	6.50 ± 0.68 (4.8)	5.1 ± 0.9 (3.4)	5.9 ± 0.9
8–9 years	6.3 ± 1.0 (3.8)	4.9 ± 1.0		6.72 ± 0.80 (4.72)	6.61 ± 0.75 (4.7)	5.4 ± 0.9 (3.6)	5.9 ± 0.5
9–10 years	6.3 ± 1.0 (3.8)	4.9 ± 1.0		6.79 ± 0.66 (5.14)	6.71 ± 0.75 (4.8)	5.6 ± 0.8 (3.9)	6.3 ± 0.8
10–11 years	6.4 ± 1.1 (3.7)	5.2 ± 1.3		6.85 ± 0.81 (4.83)		5.7 ± 0.7 (4.2)	6.4 ± 0.9
11–12 years		5.2 ± 1.3				6.1 ± 0.8 (4.4)	7.2 ± 1.6
12–13 years		6.2 ± 2.0				6.5 ± 1.1 (4.3)	7.4 ± 1.0
13–14 years		6.2 ± 2.0				7.5 ± 1.0 (5.5)	11.6 ± 2.4
14–15 years		8.6 ± 2.4				8.8 ± 1.3 (6.2)	
15–16 years		8.6 ± 2.4					
16–18 years		9.9 ± 1.7					
18–20 years		11.0 ± 1.1					
Adult	13.3 ± 1.6 (9.3)	12.4 ± 1.6					
Nationality	USA Australia	USA	Turkey	Turkey	India	Korea	Korea
No. of cases	Not available	45	1040	1278	200	1071	233

diameter were significantly lower in newborns of Chinese background compared to newborns of Caucasian or East Indian background. When adjusted for length at birth, penile length remained significantly smaller in Chinese babies compared to Caucasian and East Indian babies.

Classification of Inconspicuous Penis

There is still confusion by defining of inconspicuous penis. It has been in a mixed use as buried penis, concealed penis, hidden penis, webbed penis, trapped penis, congenital megaprepuce, or inconspicuous penis [4]. To the best of my knowledge based on the literature review, inconspicuous penis may be a more broad term and includes webbed penis, concealed penis, buried penis, hidden penis, trapped penis, and micropenis. When tracing back inconspicuous penis to its origin, buried penis was an uncommon anomaly first described by Keyes [41] in 1919 as "an apparent absence of the penis which exists when the penis lacks its proper sheath of skin, lies buried beneath the integument of the abdomen, thigh or scrotum." Since then the terms used include buried penis, concealed penis, inconspicuous penis, hidden penis, congenital megaprepuce, trapped penis, and webbed penis [1, 5, 6, 42–45].

The classification systems of an inconspicuous penis have been proposed. The classification system by Crawford [5] includes three broad categories: concealed penis, buried penis (partial or complete), and penoscrotal webs. Maizels et al. [6] described a classification consisting of four categories based on the mechanism of concealment: buried penis (due to poor skin suspension in a child or a prominent prepubic fat in an adolescent), webbed penis (penoscrotal web), trapped penis (the shaft of the penis is trapped in scarred prepubic skin usually after circumcision), and micropenis (a normally formed penis that is less than two standard deviations below the mean in stretched length). Unfortunately, the literature has not adopted a universal classification. In 1999 Casale et al. [11] reviewed a series of 43 patients and divided cases into three groups—congenital, iatrogenic, and complex cases with obesity. Recently Hadidi [14] suggested to avoid confusing terms in literature between buried penis, congenital megaprepuce, and concealed or hidden or inconspicuous penis. By his proposal buried penis may be defined as "an apparent absence of the penis characterized by an abnormally long inner prepuce", and congenital megaprepuce used to describe patients presenting with intermittent ballooning of the genital area should be included in grade I buried penis. Concealed (hidden or inconspicuous) penis could be reserved for acquired conditions presenting later in life due to abnormal excess fat accumulation in the genital area. By Radhakrishnan et al. [12] a penis of normal size may be concealed because it is (a) buried in prepubic tissues; (b) buried and also enclosed in scrotal tissue (penis palmatus); (c) trapped secondary to phimosis, post-circumcision cicatrix, or trauma; or (d) hidden because of a large hernia or hydrocele. To the best of my knowledge based on the literature review, a concealed penis has been commonly in a mixed use as buried penis. Concealed penis may be a more board conception and may cover buried penis, trapped penis, and webbed penis.

Taken together an inconspicuous penis can be classified into five categories according to congenital vs. acquired, normal sized vs. abnormal sized, and the mechanism of concealment: buried penis, trapped penis, webbed penis (penoscrotal web), micropenis, and others (congenital megaprepuce, penoscrotal transposition) (Fig. 28.2).

Concealed Penis (Hidden Penis)

There is commonly confusion by defining of concealed penis in literature review and in clinical practice. It has been in a mixed use as buried penis, concealed penis, hidden penis, or inconspicuous penis. By Gillett et al. [46] a concealed penis can be classified into two types: primary and secondary. Primary concealment (or buried penis) that is commonly associated with phimosis is thought to result from a prominent prepubic fat pad, fibrotic or inelastic dartos fascia tethering the corporeal bodies proximally, and poor attachment of the

penile skin to deeper layers at the base of the penis. Secondary concealment (or trapped penis) results from overzealous circumcision leading to an iatrogenic shortage of penile skin and entrapment of the penile shaft by a scarred preputial opening [13]. On the other hand by Maizels et al. [6], concealed penis is a congenital condition in which the penile shaft is retracted into subcutaneous tissue and completely or partially obscured by prepubic skin. The importance to differentiate concealed penis from buried penis cannot be overstated, because they are two different entities needed to be treated differently; concealed penis is a surgical condition, whereas the latter responds well to

Fig. 28.2 Various types of inconspicuous penis. Inconspicuous penis may be a more broad term and includes buried penis (**a**), trapped penis (**b**), webbed penis (**c**), micropenis (**d**), and others, congenital megaprepuce (**e**) and penoscrotal transposition associated with hypospadias (**f**)

Fig. 28.2 (continued)

Fig. 28.2 (continued)

conservative treatment, including dietary treatment and exercise [6, 10]. By Chang et al. [4], according to the original description, buried penis is a true congenital concealment disorder of the penis, and, yet, it has sometimes been confused with "concealed penis," an acquired condition associated with thick suprapubic subcutaneous fat pad in an obese boy [4]. By Borsellino et al. [8] more widely defined a concealed penis is as a phallus of normal size buried in prepubic tissue (buried penis), enclosed in scrotal tissue (webbed penis), or trapped by scar tissue after penile surgery (trapped penis). Concealed (hidden or inconspicuous) penis could be reserved for acquired conditions presenting later in life due to abnormal excess fat accumulation in the genital area [8].

Taken together, a concealed penis is a normally developed penis that is camouflaged by the suprapubic fat pad, and this may be congenital, or it may also occur iatrogenically, especially after circumcision. Therefore it can be classified into buried penis, trapped penis, and webbed penis.

Buried Penis

The buried penis is not a common condition and an abnormal appearance of the penis resulting from diverse etiologies, including sinking of the penis under excessive suprapubic fat, tethering and shortening of the penis by abnormal fibrous bands of dartos fascia, poor penile skin fixation at the penile base, and deficient outer penile skin [7, 9–11, 46–51]. It presents with a diverse spectra of severity with regard to each factor and combinations thereof [7]. A buried penis is a normally developed penis that is camouflaged by the suprapubic fat pad, and this may be usually congenital or sometimes acquired, and this is partially or completely concealed within the subcutaneous tissues [5]. In infants and young children, buried penis is a congenital abnormality in which the phallus is concealed within the subcutaneous tissue. This could be because of excessive fat in the prepubic area of the anterior abdominal wall or due to a deficiency in penile skin with abnormal mobility over the shaft. Abnormal bands between Scarpa's fascia and Buck's fascia have been reported to bind the penis. It is important to remember that the penile shaft is normal in boys with this condition, and the excessive redundancy or abnormal anchoring of the surrounding tissue makes the penis look relatively diminutive. In older children and obese adolescents, the abundant fat on the abdominal wall may hide the penile shaft, resulting in acquired buried penis. [52].

Other than a "small" penis, most of these boys are asymptomatic. However, symptoms related to phimosis, such as the "ballooning" phenomenon, painful voiding, urinary tract infection, and urinary retention, are occasionally seen and can be a significant psychological concern [9, 10, 53]. On inspection, the contour of the penile shaft and the glans cannot be seen. However, careful palpation allows on to normal in size, not a microphallus. The excessive presence of the prepubic fat is easily discernible on inspection and seems to hang over the base of the penis. On physical examination, the penis is buried below the surface of prepubic skin but can be palpated and visualized by applying pressure on the opposite side of the shaft base [10]. The excessive presence of the prepubic fat is easily discernible on inspection and seems to hang over the base of the penis.

In general the surgical correction of the buried penis is necessary not only for cosmetic reasons but also for urinary retention, urinary tract infection, and difficult voiding caused by associated phimosis [10, 48, 53]. It has been reported that surgical correction of the buried penis is a difficult challenge. Numerous techniques with their short-term results have been described to correct the buried penis and differ according to the incision lines and covering techniques. Surgical outcomes are generally excellent, with satisfactory results reported in 87–99 %, and complications are minimal with these series. A 1–15 % frequency of secondary concealment is reported, with most requiring further surgery [4, 5, 7–9, 11–13, 46, 50, 54, 55]. The indications for this type of surgery and the timing of reconstruction are controversial. More detailed information of concealed penis will be described in the next subchapter.

Trapped Penis

Trapped penis was first described by Byars and Tries [56] in 1958. Trapped penis is an acquired form of inconspicuous, concealed form and is usually the result of thoughtless circumcision of a concealed penis; less frequently, it can be the result of surgery for other pathological features [6]. It is a term usually used to describe poorly designed circumcision in a child with a buried penis and presents with a penis retracted behind the circumcision scar in a buried penis. This deformity may mainly occur after neonatal circumcision in a baby who has significant scrotal swelling, due to a hydrocele or hernia, or after routine circumcision in a baby with a webbed penis [52]. These boys may present with recurrent UTI, phimosis with ballooning during urination, or even urinary retention [52]. The physical examination reveals scar tissue from previous procedure with abnormal adhesions. The glans may not be visible in these patients or may be seen with deforming adhesions or scar tissue.

Previously, the management of the trapped penis had been primarily surgical, but this has become less necessary with the use of topical steroids. In one study, secondary phimosis with a trapped penis occurred in 2.9 % of neonatal circumcision [57]. In some cases application of topical steroids for 6 weeks after forceful dilation of the cicatrix with a fine hemostat in the outpatient clinic is effective and avoids a subsequent operation in two-thirds of infants [58]. Radhakrishnan et al. [18] demonstrated that among 14 boys diagnosed with a trapped penis, 11 boys did not need further surgical correction. If topical steroid application is ineffective, surgical correction is necessary.

The surgical technique is similar to that for buried penis. Satisfactory results are obtained again through a ventral midline incision [14]. Special care has to be taken as in those children there are very limited skin and preputial inner mucosa which may be needed to eventually cover the penis [14].

Webbed Penis (Penoscrotal Web)

The webbed penis is a congenital condition in which a web or fold of skin obscures the penoscrotal angle in an otherwise normal-sized penile shaft [6]. This is normally the result of abnormal dartos bands anchoring the penile skin on the surface of the scrotum. This results in the obliteration of ventral penoscrotal angle and resultant appearance of a short penis. It has also been referred to as penis palmatus [1, 59]. Webbed penis or penoscrotal web is a different entity from buried penis as the anomaly involves only the inferior penoscrotal junction, and the penis is not truly buried [14]. It is a condition in which the scrotal skin extends onto the ventrum of the penis.

Physical examination of these boys will show lifting up of scrotal skin when the penis is moved to lie flat on the anterior abdominal wall. The penoscrotal fusion could extend from the preputial skin to the scrotal wall. When this condition is congenital, the penis, the urethra, and the remainder of the scrotum typically are normal, and the deformity represents an abnormality of the attachment between the penis and the scrotum. This may also occur and be acquired after circumcision or other penile surgeries [52]. El-Koutby Montasser et al. [60] proposed a new classification of webbed penis based on the experience of a total of 5,881 babies aged from 1 day to 6 months and suggest an operative technique that can be planned according to the severity of webbing.

Although the webbed penis is asymptomatic in nearly all of the patients, the cosmetic appearance is often unacceptable by the child and parent. The surgical technique is different than buried penis. Several surgical techniques have been proposed for webbed penis under a variety of different terminologies [49, 54, 60–62]. However, in general, the surgical correction can be easily achieved by a V-shaped midline incision that drops the scrotal skin down away from the penis. More detailed information of webbed penis will be described in the next subchapter.

Micropenis

Definition

Micropenis is part of a larger group of conditions broadly known as inconspicuous penis. The definition of micropenis hinges on the idea of stretched penile length (SPL). SPL was first introduced by Schonfeld and Beebe [63]. Micropenis is a normally formed penis and is defined as an SPL 2.5 standard deviations (SD) less than the mean for age group without the presence of any other penile anomalies, such as hypospadias [20, 22, 64, 65]. Patients who have micropenis have a 46,XY karyotyping with gonads that are exclusively testicular without any signs of hypospadias [36]. Typically the ratio of the length of the penile shaft to its circumference is normal. In general, full-term newborns must achieve a measurement of less than 2.5 cm, or 1 inch, at least 1.9 cm, to meet the definition of micropenis [20, 23, 36, 52, 64, 66].

Early recognition of abnormalities of phallic size in prepubertal boys is important both medically and psychologically because this may be

the only or the earliest discernible clinical manifestation of hypothalamic-pituitary-gonadal axis hormonal deficiencies. Small phallic size is also one of the features of several genetic syndromes [19–22]. Therefore the exact penile size is also important in the diagnosis of penile problems such as micropenis. However, up to now there are still scarce data on the penile length measurements in children beyond the neonatal period. Studies of penile length in older children have been rarely conducted, especially in a wide range of age groups.

Classification of Causes

Knowledge of understanding the regulation of penile development allows an understanding of how micropenis occurs. Micropenis is a result of a hormonal abnormality occurring after 12 weeks of gestation [19]. There are numerous causes of micropenis including isolated gonadotropin defects without involvement of other organ systems and generalized endocrinopathies that may be associated with central nervous system defects. The causes of this condition can be divided into three broad groups: hypogonadotropic hypogonadism (pituitary/hypothalamic failure), hypergonadotropic hypogonadism (primary testicular failure), and idiopathic hypogonadism [19, 23, 66, 67] (Table 28.2).

Table 28.2 Etiology of micropenis

I. Deficient testosterone secretion
A. Hypogonadotropic hypogonadism
1. Isolated, including Kallmann syndrome
2. Associated with other pituitary hormone deficiencies
3. Prader-Willi syndrome
4. Laurence-Moon syndrome
5. Bardet-Biedl syndrome
6. Rud syndrome
B. Primary hypogonadism
1. Anorchia
2. Klinefelter and poly-X syndromes
3. Gonadal dysgenesis (incomplete form)
4. Luteinizing hormone receptor defects (incomplete forms)
5. Genetic defects in testosterone steroidogenesis (incomplete forms)
6. Noonan syndrome
7. Trisomy 21
8. Robinow syndrome
9. Bardet-Biedl syndrome
10. Laurence-Moon syndrome
II. Defects in testosterone action
A. Growth hormone/insulin-like growth factor-I deficiency
B. Androgen receptor defects (incomplete forms)
C. 5-α reductase deficiency (incomplete forms)
D. Fetal hydantoin syndrome
III. Developmental anomalies
A. Aphallia
B. Cloacal exstrophy
IV. Idiopathic
V. Associated with other congenital malformations

Adapted and used from Campbell-Walsh Urology. 9th ed. [52]

Hypergonadotropic hypogonadism (primary testicular failure) Micropenis secondary to hypergonadotropic hypogonadism may result from Leydig cell damage resulting in insufficient testosterone secretion [68]. The most common cause of hypergonadotropic hypogonadism is Klinefelter syndrome, and others include gonadal dysgenesis, cryptorchidism, vanishing testes syndrome, Leydig cell aplasia, Noonan syndrome, myotonic dystrophy, mumps orchitis, testicular torsion, and so on.

Hypogonadotropic hypogonadism Hypogonadotropic hypogonadism can present initially with micropenis, which allows it to be diagnosed shortly after birth [69]. Hypogonadotropic hypogonadism is the failure of the hypothalamus to secrete gonadotropin-releasing hormones (GnRH) that normally stimulate the pituitary gland to secrete the gonadotropins luteinizing hormone (LH) and follicle-stimulating hormone (FSH) [70]. The hypothalamic-pituitary function is otherwise normal in most patients, and hypothalamic-pituitary imaging reveals no space-occupying lesions. The common causes of hypergonadotropic hypogonadism are panhypopituitarism, isolated gonadotropin deficiency, Kallmann syndrome, Laurence-Moon syndrome, constitutional delay of growth and puberty (CDGP), isolated luteinizing hormone deficiency, Prader-Willi syndrome, and so on.

Idiopathic hypogonadism Idiopathic shows normal hypothalamic-pituitary-gonadal axis [23].

Evaluation

Evaluation of the external genitalia is an important part of the neonatal physical examination in newborn males. The early diagnosis of micropenis is very important in several views. First, from a psychological point of view, it sends the message to the parents that genital development might be abnormal in their newborn, a very traumatizing experience even if the investigations later show that the baby is actually a perfectly normal male infant. Second, from a clinical point of view, it implies that several additional investigations (i.e., hormonal determinations, karyotype, ultrasound) might be necessary in order to rule out pathological causes of micropenis. Last but not least, a diagnosis of micropenis, whether part of a defined endocrine or genetic condition or labeled as "idiopathic," must be made early in life and has implications from a therapeutic point of view, as injections of testosterone will usually be considered [31, 71].

Once micropenis is confirmed through physical exam, consultation with the endocrinology service should be obtained to help determine the cause of micropenis as well as to rule out possible life-threatening associated abnormalities [23]. The endocrine evaluation of child with micropenis is not standardized. Serum testosterone, 5a-dihydrotestosterone (DHT), luteinizing hormone (LH), and follicle-stimulating hormone (FSH) for basal assessment of testicular function should be performed in boys with micropenis [52]. Levels of other pituitary hormones may also be measured when needed. Some authors advocate obtaining a karyotype for genetic disorder especially Klinefelter syndrome, although this recommendation is not universal [20, 22, 52]. If serum LH and FSH levels are high, it stands for primary testicular failure. On the other hand if those levels are low it implies secondary hypogonadism. If the child shows short stature, delayed pubertal development, and low serum LH and FSH levels, it may represent constitutional delay of growth and puberty [72]. Increased serum FSH level means a failure or problem in the sperm production [73].

Table 28.3 Human chorionic gonadotropin (hCG) stimulation test

Procedure:
Day 0: take blood for testosterone, androstenedione, and dihydrotestosterone (DHT). Administer 1500 units (infants) or 5000 units (over 2 years) hCG subcutaneously or intramuscularly
Day 4: take blood for testosterone, androstenedione, and dihydrotestosterone
Interpretation:
There is a two- to ninefold increase in testosterone in normal prepubertal boys
In the absence of testes, no response in testosterone occurs
Normal males show a complex pattern of testosterone. In the first week there is a mostly elevated testosterone concentration due to gonadal stimulation by maternal hCG. During a period with 2–6 months of age, testosterone should reach the lower end of the adult range associated with adult gonadotropins (LH > FSH). Thereafter testosterone becomes undetectable until the onset of puberty
There are reported errors in the interpretation of the hCG stimulation test in boys of approx 8 years with increased T/DHT ratios in the 5α-reductase range

Adapted and used from http://www.pathology.leedsth.nhs.uk/dnn_bilm/Investigationprotocols/hCGStimulationTest.aspx [74]

In some cases a gonadotropin-releasing hormone (GnRH) stimulation test is also necessary (Table 28.4)

Endocrinologic assessment helps determine at what level the cause of micropenis is in the hypothalamic-pituitary-testicular axis. In addition to evaluation of central endocrine functions, testicular functions also need to be evaluated simultaneously. Basically testicular function may be assessed by measuring serum testosterone level before and after human chorionic gonadotropin (hCG) stimulation test (Table 28.3). Primary testicular failure produces an absent response and elevated basal concentration of luteinizing hormone (LH) and follicle-stimulating hormone (FSH). Antimüllerian substance (AMH), also known as müllerian-inhibiting substance (MIS), and inhibin B, which are produced by functioning Sertoli cells, can also be used to determine the presence of functional testicular tissue. Low AMH coupled with a normal inhibin B is indicative of the rare, persistent müllerian duct syndrome, which is the result of a defect in the gene that encodes AMH [75, 76].

Table 28.4 Gonadotropin-releasing hormone (GnRH) stimulation test

Procedure:
Obtain blood samples for baseline LH and FSH
Inject 2.5 ug/kg maximum of 100 ug GnRH (IV)
Obtain blood samples for LH and FSH at 15, 30, 45, 60, and 120 min
Interpretation:
Central precocious puberty and normal puberty: twofold or higher increase in FSH and LH
In gonadal failure the response is exaggerated
In gonadotropin-independent precocious puberty the LH and FSH response is suppressed
The test will not definitely distinguish pubertal delay from hypogonadotropic hypogonadism

Adapted and used from http://imperialendo.co.uk/paedend1.pdf [77]
LH luteinizing hormone, *FSH* follicle-stimulating hormone

Before extensive evaluation of the hypothalamic-pituitary-testicular axis, low-dose androgen stimulation test should be done to determine the end-organ (testis) response. Although prolonged treatment might advance skeletal maturation, short courses of treatment do not affect height. For androgen stimulation test, in general intramuscular testosterone enanthate has been used and transdermal testosterone also has been used.

Anterior pituitary screening tests include serial measurements of serum glucose, sodium, potassium, and cortisol concentration and thyroid function tests [52]. Pelvic ultrasound can be used to visualize internal genital organs in suspicious cases. Magnetic resonance imaging of the head could be done to determine the anatomic integrity of the hypothalamus and the anterior pituitary gland as well as the midline structures of the midbrain such as pituitary stalk dysplasia syndrome, central diabetes insipidus (indicated by a lack of a posterior pituitary bright spot), and pituitary aplasia [20, 23, 75, 78, 79].

Management

Treatment of micropenis should focus on penile size sufficient for the patient to have an appropriate body image, normal sexual function, and standing micturition [20, 23].

Management of micropenis can vary according to cause of hypogonadism. However, in general, short-term androgen replacement is necessary before puberty, and then long-term androgen replacement should be needed after puberty. Treatment is directed toward providing adequate androgen replacement conveniently and safely. In rare cases without response to androgen replacement, surgical correction may be needed [23].

Gonadotropin replacement Recombinant human FSH-LH treatment during the first few years of life promotes an increase in testicular growth and penile length in patients with hypogonadotropic hypogonadism, although this effect is not very significant [22]. Main et al. [69] reported an increase in penile length from 1.6 cm to 2.4 cm and a 170 % increase in testicular volume evaluated by ultrasonography in a patient with micropenis, when testosterone treatment was added to subcutaneous injections of 20–21.3 IU of recombinant LH and FSH twice a week, for a duration of 6 months. Some adverse effects reported included increased body hair and pigmentation as well as intermittent nausea.

Androgen replacement Primary treatment of micropenis revolves around exogenous testosterone administration to increase the length of the penis. Long-term androgen replacement is not recommend in children less than 12 years old with micropenis because of unexpected early virilization and bony maturation. In order to observe initial progress, four doses of 25 mg of testosterone cypionate or enanthate in oil are administered intramuscularly once every 3 weeks for 3 months. Side effects are minimal; however, it may cause temporary acceleration in growth rate and in advancement of bone age [22, 80]. However, if the response is not deemed satisfactory, repeat administrations over short time periods may be performed without significant concern about early maturation of bony growth plates and subsequent reduction in stature [75, 81]. Topical testosterone application is effective during infancy. Arisaka et al. [82] demonstrated increases in penile lengths in 50 infants and children aged between 5 months and 8 years, by administering 5 % testosterone cream for a duration of 30 days. Most authors endorse 25 mg of intramuscular testosterone in

infancy, typically in its ethanate formulation, to promote longer action, once a month for 3 months, followed by further courses at higher dosages at the start of pubarche [52, 66, 75, 81]. The appropriate timing of androgen therapy for the treatment of micropenis is controversial. Menon and Khatwa [22] proposed that an important aspect of testosterone treatment is the recommendation to begin treatment early in infancy and childhood. Patients with hypogonadotropic hypogonadism show a decrease in penile androgen expression. There is a natural decrease in androgen receptors in early adulthood, and so the early administration of testosterone allows for increased penile androgen receptor concentration and duration during the period before this decline. On the other hand opponents of early hormonal therapy point out that infantile and preteen hormonal therapy only brings about premature growth of the penis with the late adolescent and adult still having micropenis [83, 84]. Empirical evidence indicates that testosterone treatment has a positive impact on penile growth during infancy, yet it is unclear whether the growth will continue during adolescence and adulthood [85]. Males who have no signs of puberty and are near age 15 may be given long-acting testosterone enanthate 50 mg IM once/month for 4–8 months. These low doses cause some virilization without restricting adult height. Older adolescents with testosterone deficiency receive long-acting testosterone enanthate or cypionate at a dose that is increased gradually over 18–24 months from 50 to 100 to 200 mg IM every 1–2 weeks. Transcutaneous gel may also be used and is more difficult to accurately dose. It is reasonable to convert older adolescents to testosterone gel 1 % at adult dosages when their IM dosage has reached the equivalent of 100–200 mg every 2 weeks. Options for replacement therapy include testosterone gel 1 % (5–10 g daily to deliver 5–10 mg daily), IM testosterone enanthate or cypionate (100 mg every 7 days or 200 mg every 10–14 days), a buccal mucosal patch (30 mg bid), or a transdermal testosterone patch (5–10 mg daily). Testosterone gel maintains physiologic blood levels more consistently than other treatments, but IM or patch systems are sometimes used because of their lower cost.

If the penis does not respond to testosterone, the question of whether to recommend gender reassignment is controversial. If endocrine treatment does not accomplish a satisfactory result, surgical therapy can offer an alternative in the management of micropenis [20, 86, 87]. According to some studies, although ultimate penile size may not fall within what is considered a normal range, men born with micropenis have a male gender identity, and the majority can have satisfactory sexual function [52]. Therefore sex reassignment with creation of female genitalia for patients with this condition should be undertaken with extreme caution and should only be done by those with a large amount of experience. Because most likely the biggest problem associated with the management of micropenis is the lack of knowledge in terms of long-term outcome.

Constitutional delay of growth and puberty (CDGP) Constitutional delay of growth and puberty (CDGP) is one of the most frequent reasons for referral of short children to pediatric endocrinologists. In general, children with CDGP have: (1) short stature with a height standard deviation score (SDS) that is 2 standard deviations (SD) for chronologic age or target height; (2) height velocity below 25th percentile for chronologic age; (3) delayed bone age; (4) no evidence of systemic illness, genetic syndrome, or endocrine disorder; and (5) pubertal onset at an age greater than 2 SD of average maturers (>14 years in boys and >13 years in girls) [73]. Testosterone is generally limited to boys whose bone age is 12 years or greater. Fifty to 100 mg of Depo-Testosterone monthly is given for 3–6 months. Because normal pubertal growth requires both androgen and an increase in GH production, a rapid increase in growth velocity essentially excludes the possibility of GH deficiency and obviates the need for GH stimulation testing. Most of the testosterone administered will have been cleared by approximately 15 days after the injection, allowing adequate time for the hypothalamic-pituitary axis to recover from any suppression induced by testosterone. If, during this course of therapy, signs of puberty (testicular

enlargement) are noted and progress after discontinuation of sex steroids, the diagnosis of CDGP is confirmed [73].

Others

Congenital Megaprepuce

The congenital megaprepuce is a very rare malformation of unknown etiology, with anatomical findings similar to those observed in the congenital buried penis [42]. It is a condition where the infrapreputial skin is lifted off its attachments to deep fascia due to an extraordinarily bulky preputial tissue [1]. O'Brien et al. [88] first reported a particular subgroup characterized by excess intermittent ballooning of the genital area after micturition due to urine retention. They called this subgroup of buried penis "congenital megaprepuce." Shenoy [45] and Ferro [42] believed that congenital megaprepuce is a different entity from buried penis and the plan of surgical management should be different. The megaprepuce is associated with intermittent swelling of the genital region, due to urine retention in the preputial space. Compression of this swelling results in urine spillage. The containment of stagnant urine and subsequent inflammation of the inner surface of the abnormal preputial space can cause dysuria and urinary infection [14, 42].

Penoscrotal Transposition (Scrotal Engulfment)

Penoscrotal transposition may be partial or complete. Frequently, the condition occurs in conjunction with perineal, scrotal, or penoscrotal hypospadias with chordee [52]. When there is complete penoscrotal transposition and a normal scrotum, as many as 75 % of patients have a significant urinary tract abnormality, and renal sonography and voiding cystourethrography should be performed [52]. More detailed information of penoscrotal transposition will be described in the next subchapter.

Management of Inconspicuous Penis

Surgical Management

The presence of concealed penis can lead to phimosis, balanitis, and difficulties with hygiene and can be a significant source of anxiety. Functional and psychological concerns resulting from inconspicuous penis, especially buried penis, have been widely described, and early surgical treatment has been widely advocated by pediatric urologists and pediatric surgeons. Although inconspicuous penis can result in hygiene problems, voiding difficulty, or embarrassment among peers, it is not a life-threatening illness. Therefore, it is important to consider the patient's and parents' wishes when considering correction.

Treatment of concealed penis is still controversial. However pediatric urologists believe that surgery should be performed if concealment causes difficulty during voiding or trapped urine, which results in difficult hygiene. These patients may present with balanitis, a urinary tract infection, or even urinary retention. Additionally, parental and patients' cosmetic anxiety regarding a small nonvisible phallus is another concern [10, 11, 46, 50, 55]. Up to now most of the studies have shown that patients and families are generally very pleased with surgical outcomes [4, 5, 7–9, 11–13, 46, 49, 50, 54, 55].

Another controversial issue is the ideal age for surgery. Shapiro [3] stated that boys with a buried penis are conscious of the problem even before puberty and that with persistent concealment of the penis the child's later psychological development would be improved by correcting the problem earlier, rather than later. Ferro [42] and Philip [43] recommended correction as soon as the diagnosis is made, in order to resolve both the dysuria and the cosmetic anomaly. Casale [11] proposed that the correction of concealed penis should be performed after the child is walking and abdominal fat has diminished. Radhakrishnan [12] suggested that, in the infant, if the buried penis has not resolved by 2–3 years of age, it will require correction. Herndon [7] demonstrated that the parents thought that surgery is almost uniformly successful in toddlers and less often successful in adolescents. Given the increased

risk in adolescence, it may be advisable to consider early intervention in cases of concealed penis. Moreover, as with all genital malformations, early surgical intervention (at 6–12 months of age) is advocated to avoid the psychological problems [8]. By Gillett et al. [46] waiting for pubertal hormonal changes to correct the problem is usually unsatisfactory to parents and patients. They believe that early surgery improves the self-image of the patient and relieves parental anxiety. Therefore they recommended surgical correction before school age.

Numerous techniques have been described to correct inconspicuous penis especially concealed penis with various surgical outcomes. Much of the variation can be ascribed to the presumed cause of the defect and attempts to simplify the approach. Although many surgical techniques for correction of concealed penis have been described in the last few decades, using unfurled preputial skin to cover the penile shaft and complete penile degloving has been a basic principle of correction, as there are dysgenetic dartos fibers between the skin and the penis. Furthermore, the importance of fixation sutures between the dermis, the skin, and the Buck's fascia at the penile base has been emphasized [6, 7, 10, 13, 53]. However, no single universally accepted method exists for all inconspicuous penis repairs. New surgical techniques are warranted to reach better cosmetic outcomes. Several long-term follow-up studies demonstrated that surgery is a reliable means to address this clinical entity and alleviates patients' or parents' negative concerns [6, 7, 13, 53]. More detailed information of surgical correction of inconspicuous penis will be described in the next subchapter.

Conservative Management

Management of the concealed penis continues to evolve, with several manuscripts having been published over the last several years. Each describes a novel surgical approach, as well as outcome data. Recently a nonsurgical, conservative approach has also been published.

Concealed penis secondary to excessive suprapubic or prepubic fat does not need surgical correction because the excessive fat pad most often disappears with growth, yielding a normal appearance by puberty [1, 89]. In the last few decades ago, it had already suggested that surgical correction for a concealed penis resulting from an acquired condition associated with thick suprapubic subcutaneous fat pad in an obese boy is unnecessary, because the condition is self-correcting [5, 48]. Donahoe and Keating [48] proposed that the concealed penis, hidden behind overlying prepubic fat in obese patients, requires no therapy since induced erection reveals adequate shaft skin coverage. The results from observation have recently been reported by Radhakrishnan et al. [18]. They stated that they observed all infant patients with a concealed penis until the age of 2–3 years and operated on anyone older than this. From all of their patients, there appears to be a 29 % chance of success with spontaneous resolution, and this increases to 58 % if one only includes children under the age of 3 years. Resolution was ascribed to the diminution of the prepubic fat and elongation of the lower abdomen [18, 50]. From the standpoint of adult urologists, they argue they do not see concealed penis conditions in adults. Whether this condition corrects itself at puberty is still not answered [10, 90].

Conclusions

Inconspicuous penis refers to a group of conditions that the penis appears to be small but the shaft can be normal or abnormal in size and is a common condition presenting to a pediatric urologist. However, up to now there is still confusion by defining of inconspicuous penis in the literature review and in the clinical practice. Inconspicuous penis causes often psychologically negative effects, low self-esteem, and anxiety to the child or family. The psychological pressure on children and their parents can be enormous over time, and counseling may well have an important role in the correction of inconspicuous penis. Reconstruction is warranted in appropriate cases to avoid future psychosexual issues and provide the child with normal functional anatomy. The inconspicuous penis can be due to a variety of causes, and this understanding

is essential for a satisfactory repair. In some cases observation is a viable option, especially for the neonate. Surgical outcomes are generally excellent and most complications are temporary with minimal rate of reoperation. Most of studies demonstrated that short-term outcomes are satisfactory; therefore more studies of long-term follow-up will be necessary. Taken together the early evaluation of the genital development is important both medically and psychologically, and the exact assessment of this is also important in the diagnosis and management of penile problems.

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Webbed Penis

29

Kang Su Cho

Introduction

The webbed penis is a deformity in which a web of skin obscures the penoscrotal angle in an otherwise normal-sized penile shaft; another term penoscrotal fusion has been also used [1]. This condition can be either congenital or acquired. The latter is known to be more common and mainly iatrogenic, and the representative example was the deformity caused by excessive skin removal during circumcision. The former is relatively uncommon and a disease of penile and scrotal hypoplasia. The embryological explanation of webbed penis may be that there is a partial failure of the posterior migration of the labioscrotal folds [2]. This anomaly can be also explained embryologically on the basis of a disturbance in the development of the prepuce [3]. Initially the glans penis is devoid of any ectodermal covering. As development continues, the ectodermic layer on the dorsal aspect of the penis grows and ultimately covers the entire penis. An error in this phase of development may cause penoscrotal fusion [4]. A prospective survey demonstrated that the webbed penis was found in 4 % of babies (236/5,881) [5].

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In 1986, Maizels et al. described the webbed penis as a subtype of the concealed penis; they classified the concealed penis into normal circumcised, poor skin suspension, buried penis, webbed penis, trapped penis, and micropenis [1]. In 2010, El-Koutby and El Gohary proposed a new classification of the webbed penis as shown in Table 29.1 [5] (Table 29.1).

Webbed penis usually causes no problems in children except for poor appearance and pseudo-small penis [6, 7]; thus there might be the controversy on the necessity for surgery in childhood. However, webbed penis can cause penile curvature, difficulty in penetration, discomfort during intercourse, problem in wearing a condom, and psychological stress in adulthood [8]. For these reasons, it is generally recommended that a webbed penis should be corrected during infancy.

Surgical Technique

The purpose of surgical repair is to put the penis apart from the scrotum, and a well-defined penoscrotal junction gives the penis a longer appearance after successful correction. The basic principle of the most successful technique is that the ventral shaft should be wrapped with inner or outer preputial skin as the scrotal skin is hair bearing and future intercourse could be difficult or uncomfortable. Excision of scrotal skin is not recommended, because it may result in lack of skin and scar contracture. A circumcision should

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Table 29.1 Classification of the webbed penis proposed by El-Koutby and El Gohary

1. Primary webbed penis
A: Simple
Grade 1: The web extends to the proximal 1/3 of the shaft of the penis
Grade 2: The web extends to the mid 1/3 of the penis
Grade 3: The web extends to the distal 1/3 of the penis
B: Compound
Type 1: Web with prepenile scrotum
Type 2: Web with penile curvature
Type 3: Broad web
2. Secondary webbed penis
Postcircumcision: In obese children or concealed penis

be considered at the same time because it facilitates the approximation of the skin.

In cases of mild anomaly, a modified circumcision can be sufficient to correct deformity (Fig. 29.1). However, various surgical techniques such as Heineke-Mikulicz repair, V-Y advancement technique, and Z-plasty should be employed in most cases. Heineke-Mikulicz repair can be performed by incising the web transversely and closing it longitudinally, thereby separating the penis from the median raphe of the scrotum (Fig. 29.2). V-Y advancement technique is familiar to the urologist as a technique for penile lengthening procedure;

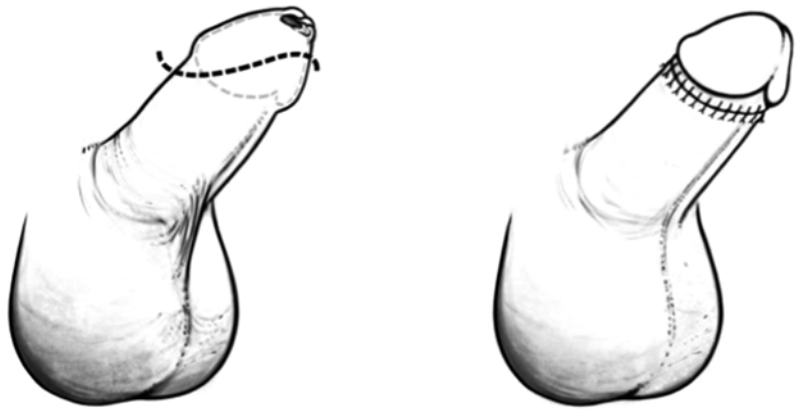

Fig. 29.1 A modified circumcision. In relatively simple cases, penoscrotal webbing can be easily corrected with a simple modification of standard circumcision. The ventral skin incision is made more distally than usual, at the phimotic band. This enables the inner or outer preputial skin to cover the ventral penile shaft

Fig. 29.2 Heineke-Mikulicz repair. The transverse incision is made on the web and subsequently closed longitudinally; therefore the penile shaft can be separated from the median raphe of the scrotum

Fig. 29.3 V-Y advancement technique. A V-figured incision was made on penoscrotal web; a triangular skin flap was elevated and mobilized. The wound was repaired to form a Y-figured suture line. To correct the web completely, the repeated V-Y advancement procedure may be needed

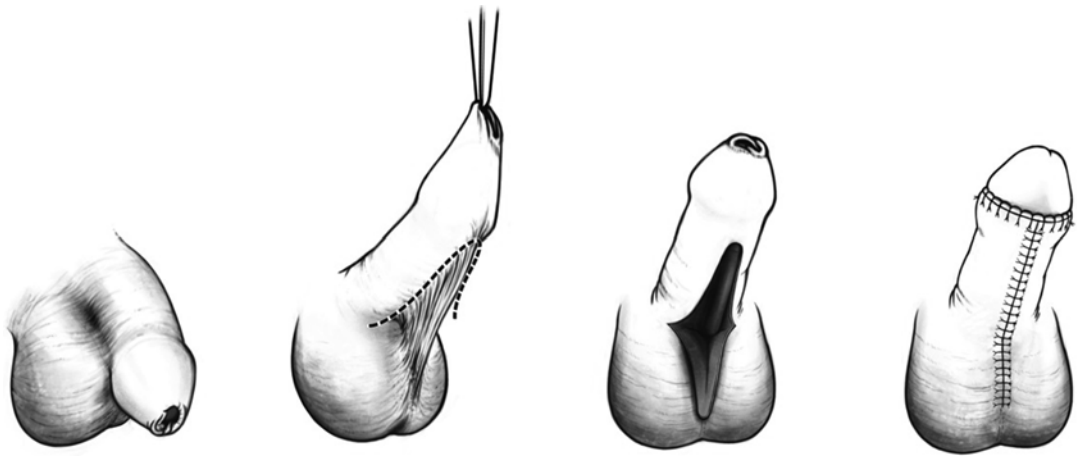

Fig. 29.4 In more severe cases of webbed penis, a U-shaped incision is made about the phallus. Skin flaps are elevated in all directions so that surgical defect can be closed. The scrotum is closed in a side-to-side manner

similarly it can be applied for the correction of penoscrotal webbing as it makes the ventral length of penile shaft longer [9] (Fig. 29.3). Single or double Z-plasty can be also used, and it can sharpen the junction and make the ventral length longer. In more severe cases of webbed penis, a U-shaped incision is made about the phallus [8] (Fig. 29.4). This releases the penis from the dependent scrotum. Flaps are developed to allow ventral closure of the penis with fine absorbable sutures. The scrotum is closed in a side-to-side manner.

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Correction of Congenital Buried Penis

30

Seung Hyo Woo

Introduction

The buried penis is a normal penis appearing inconspicuous penis that presents to be small penis with a normal stretched length (symphysis pubis to penile tip), also referred to as hidden or concealed penis [1]. Keyes in 1919 first described buried penis as "absence of the penis exists when the penis, lacking its proper sheath of skin, lies buried beneath the integument of the abdomen, thigh or scrotum" [2]. That is, the buried penis is the condition wherein the penis is submerged in suprapubic fat pad and/or scrotum by congenital or iatrogenic causes identified. I deal with only congenital form of the buried penis in the chapter.

Presentation and Classification

The buried penis is frequently encountered in pediatric urologic clinic. Patients or their parents concern and complain over abnormal penile development such as the micropenis, abnormal behaviors of urination such as problems holding the penis, the preputial ballooning or the spraying of urine, and penile infection and itching [3]. Some boys may complain to be unable to void for themselves while standing after being potty-trained. In addition, it gives rise to the discomfort following erection, especially at night in younger boys, and even handicaps relating to the sexual life may be followed in adult [4]. Consequently, these physical and psychological problems require an adequate reconstruction to normalize the penile appearance. However, we don't know the exact incidence because of the lack of prevalence survey while age at presentation is bimodal, infancy (congenital), and adolescence (acquired).

The congenital buried penis (CBP) can be classified into four types according to hidden etiologies [5–7]: (1) obesity, especially excessive fatty tissue in prepubic skin, (2) the insufficient fixation of penopubic skin to the base of penis, (3) tethering of penile skin forward on the cavernosal by inelasticity of the dysgenetic dartos fascia, and (4) the abnormal attachments of the fundiform ligament to the distal or middle shaft of the penis (Fig. 30.1). However, surgeons can frequently meet complex cases including one more etiology during operation.

Diagnosis

A buried penis is a form of inconspicuous penis and must be differentiated from other forms including a webbed penis, micropenis, penoscrotal transposition, and hypospadias.

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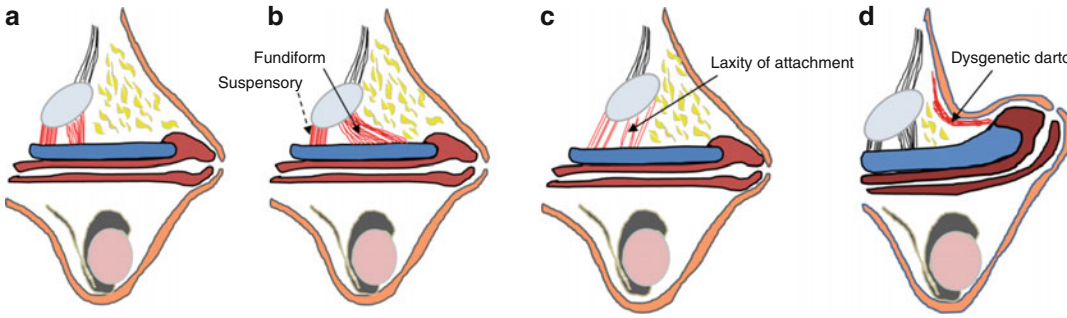

Fig. 30.1 Classification of buried penis: (**a**) excessive prepubic fatty tissue, (**b**) abnormal attachments of fundiform ligament to cavernosal, (**c**) insufficient fixation of base of penis, (**d**) tethering of penile skin due to dysgenetic dartos tissue

A buried penis, unlike other forms, has normal penile stretched length in terms of the definition and etiologies. Thus, the genital examination including the measurement of penile stretched length and the past medical history relating to this condition are essential to diagnose it. The factors affecting future therapeutic plan are a trapped penis from phimotic ring (physiologic or scaring), voiding problems, recurrent infection, pain or discomfort during erection, skin irritation, and psychological issues.

Management

The etiologies of the buried penis provide the options of therapeutic plan (Fig. 30.1). The buried penis from excessive fatty tissues (obesity) is helpful to consider the decision making for a surgical correction after a weight loss and exercise program or waiting to the puberty. In patients with the preputial ballooning or the spraying of urine during voiding, the combination of topical betamethasone and manual retraction is another medical option, which provided complete resolution in some cases and reduced surgical correction by 79 % in secondary cicatricial scarring cases [8]. In the observational study without the classification of the buried penis by etiologies, 51 infants were observed, and 29 of them spontaneously resolved by the age of 2–3 years, especially in patients with a partially buried penis [9]. However, a surgical correction may be needed if these conservative managements fail or the age is over 3 years.

Surgical Correction

A variety of surgical techniques have been described to correct the buried penis, from dorsal slit technique and inner preputial technique to the novel fixation technique with or without skin flaps or Z-plasty or V-Y plasty.

It has been used for the unfurling procedure to release the phimotic ring, and these procedures can be summarized following three methods (Fig. 30.2): (1) dorsal slit, (2) ventrally vertical incision, and (3) vertical incisions of inner prepuce and lateral incision of outer prepuce. Of course, various modified unfurling techniques are used by surgeons' preference.

However, the indication and the timing for surgical correction are controversial. Since "anatomic alignment" technique was introduced [1], the novel fixation techniques including the unfurling of phimotic ring and the release of dysgenetic dartos and/or abnormally fixed suspensory ligament have been established. Table 30.1 shows the characteristics and the outcome according to the type of technique for the congenital buried penis (Table 30.1).

The three representative techniques of the surgical correction for the buried penis are introduced here. The first (Fig. 30.3) is the advanced modification from the inner preputial technique known as the "Redmond technique" which is the only unfurling of the phimotic ring. These modifications include the excision of the phimotic ring with the ventral incision of inner prepuce or only ventral incision with the circumferential incision on the phimotic ring for the unfurling, and the

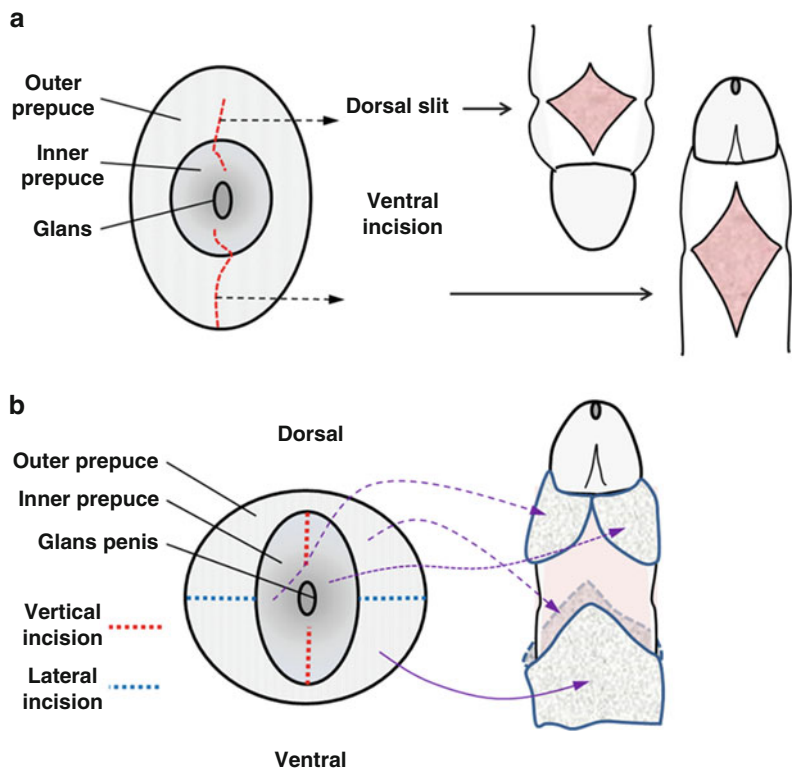

Fig. 30.2 Unfurling methods for the release of the phimotic ring: (**a**) dorsal slit (*left*) and ventral midline incision (*right*), (**b**) inner vertical and outer lateral incision, "zigzag"

Table 30.1 The outcomes according to corrective techniques for the congenital buried penis

Reference	Subjects	Unfurling	Anchoring	Follow-up (m)	Success rate	Notes
Addi et al. [10]	61	Ventral midline incision and circumferential incision on coronal sulcus	Ventral and dorsal	15 (6–48)	91 %	Long inner prepuce in all grades Abnormal attachment of ligament in all of grades 2 and 3 Partial retraction of 9 % in grades 2 and 3
Chin et al. [11]	134	Excision of phimotic ring and ventral incision	No	>3–6	Almost	Persisting edema in 1 patient Edema subsided within 1 month Abnormal fascial attachment in most cases
Kim et al. [12]	12	Ventral midline incision and circumferential incision on coronal sulcus	Ventral and dorsal	5.1	Parental satisfaction: 83.3 %	Temporary discoloration for 1 month in one patient
Liu et al. [6]	22	Excision of phimotic ring and ventral incision with penoscrotal Z-plasty	Lateral 2 points (3′ and 9′)	>6	100 %	Abnormal attachment of fundiform ligament in all cases No complication and no reoperation
Rod et al. [13]	52	Ventral incision and circumferential incision on coronal sulcus	Ventral and dorsal	61.8	Very good: 44 % Cosmetic defect: 48 %	Congenital megaprepuce type in all cases Redo surgery in 8 %

Table 30.1 (continued)

Reference	Subjects	Unfurling	Anchoring	Follow-up (m)	Success rate	Notes
Perger et al. [14]	100	Ventral incision and circumferential incision on coronal sulcus	Dorsal 3 points	12–72	96 %	Edema within 3 months Redo operation in 4 % (2 recurrence, 1 foreskin redundancy, 1 infection)
Borsellino et al. [15]	56	Circumferential coronal incision and incision on scrotal raphe	Dorsal 2 points	>12	94.7 %	Recurrence: 3 adolescents with obesity
Chin et al. [16]	22	Ventral slit and circumferential incision on the junction of inner and outer prepuce	No	>2 (at least)	–	Edema subsided within a month No persistent edema
Redman et al. [17]	31	Redmond technique (no unfurling)	No	12.3 (2–28)	–	No fascial anomaly and no requirement of unfurling in all cases Penile length: no change

When most techniques for the buried penis repair were combined, the following steps are surgically essential for successful and satisfied outcomes and minimized complications:
Unfurling: excision or incision of phimotic ring (pass this step if no phimotic ring)
Degloving of prepuce at the base of penis and under the penoscrotal junction
Remove/release the dysgenetic dartos or the fundiform/suspensory ligaments from Buck's fascia
Fixation/anchoring of Buck's fascia at the level of the base of penile shaft with nonabsorbable suture (1 or 2 points to the suprapubic dermis on the dorsal aspect and 1 or 2 points to the penoscrotal dermis on the ventral aspect)
The distal or ventral penile skin coverage by using the unfurled prepuce (trim to avoid the phimosis or the postoperatively severe preputial edema by the remained preputial skin)
At the time of skin closure, consider the correction of the penile torsion if it is being

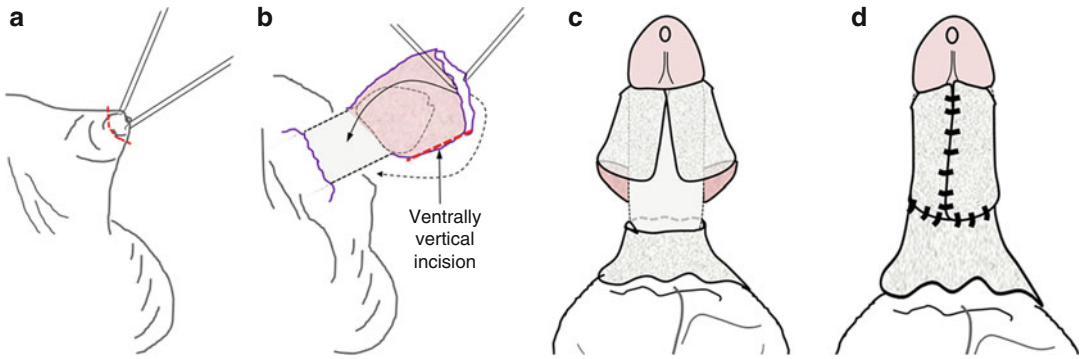

Fig. 30.3 The modified inner preputial technique: (**a**) excision or incision of the phimotic ring, (**b**) degloving the shaft to inner prepuce and release of the fibrotic tissue attached to Buck's fascia and ventrally unfurling the inner prepuce, (**c**) restoration of skin coverage of the penile shaft, (**d**) compressive dressing and skin suture

degloving and dissection of the fibrotic or dysgenetic tissues from Buck's fascia [11, 18], but may imply the possibility of retraction of penis according to the etiology because of not including the fixation step.

The second (Fig. 30.4) is a novel and the most popular technique, which includes all surgical steps mentioned above, and can be applied regardless of the etiologies of the buried penis. Brisson et al. described a technique including a combined circumferential and ventral incision followed by degloving and three fixation (anchoring) sutures [19]. Also, they did not recommend the removal of prepubic fat fad and penile fixation to the periosteum [9, 19]. Metcalfe et al. introduced additional procedures

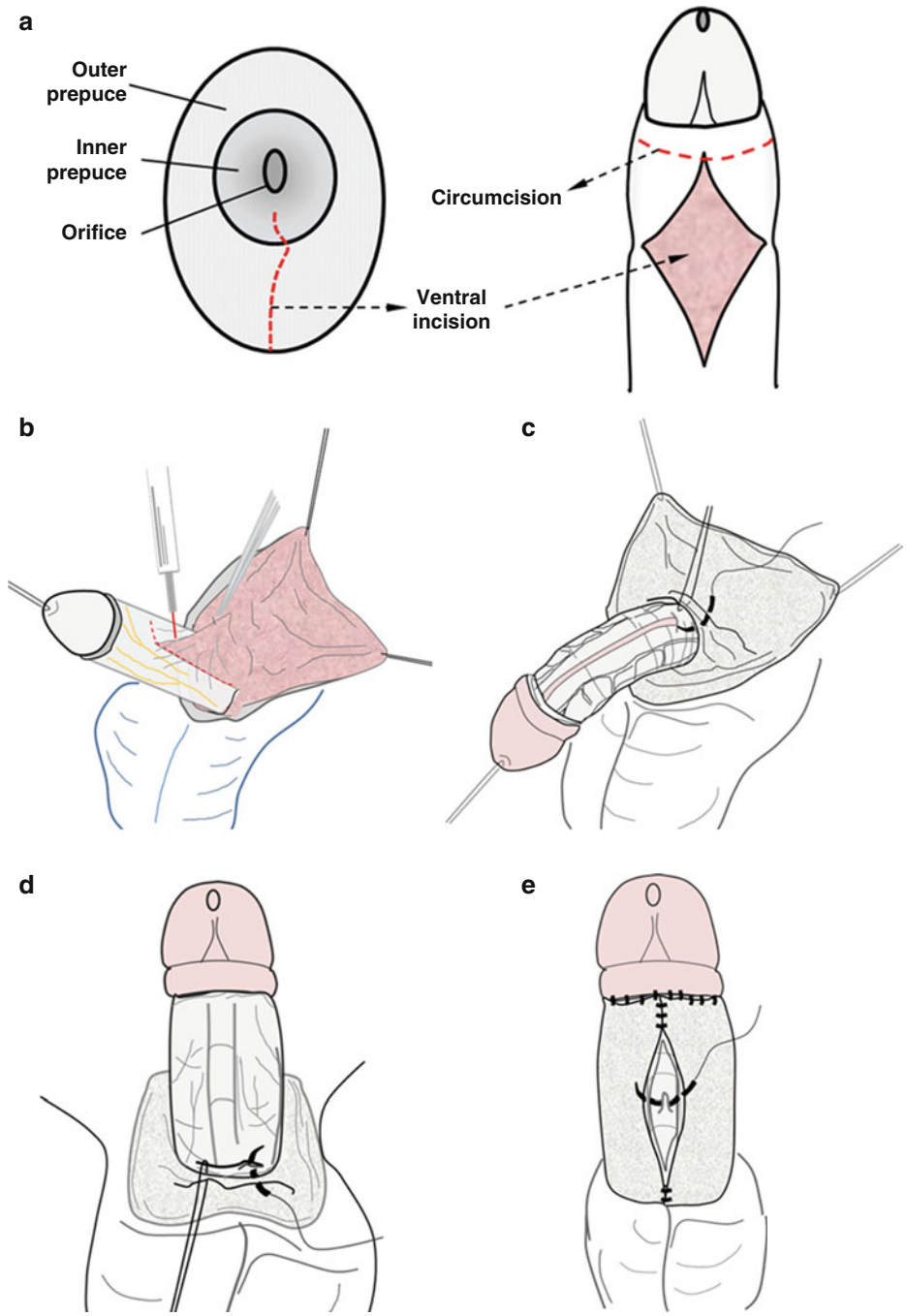

Fig. 30.4 The noble fixation technique (ventral and circumferential incision): (**a**) the ventral midline incision from phimotic ring to the penoscrotal junction, and then a circumferential incision is made around 0.5 cm from the coronal sulcus, (**b**) release of the fibrotic dysgenetic tissues and the distal attachment of the fundiform and/or suspensory ligaments attached to Buck's fascia, (**c**) two sutures fix Buck's fascia to the periosteum or prepubic skin (dermal layer), (**d**) two sutures fix Buck's fascia to the scrotal skin, (**e**) optional procedure (skin suture for the circumferential and vertical margin of skin)

tacking the dartos fascia of ventrally incisional skin to Buck's fascia of the spongiosa to minimize skin mobility and maximize the cosmetic results [20].

The last is a modified novel technique named "Zigzag" by our group [21]. This is different from the conventional novel fixation technique in some procedures. In this technique, the stay suture of the glans penis is replaced to the stay suture of inner prepuce, and the ventral and circumferential incisions are replaced to the lateral incision of the outer prepuce and the dorsal and ventral incision of the inner prepuce, so the suture and the trimming of skin are simplified (Fig. 30.5).

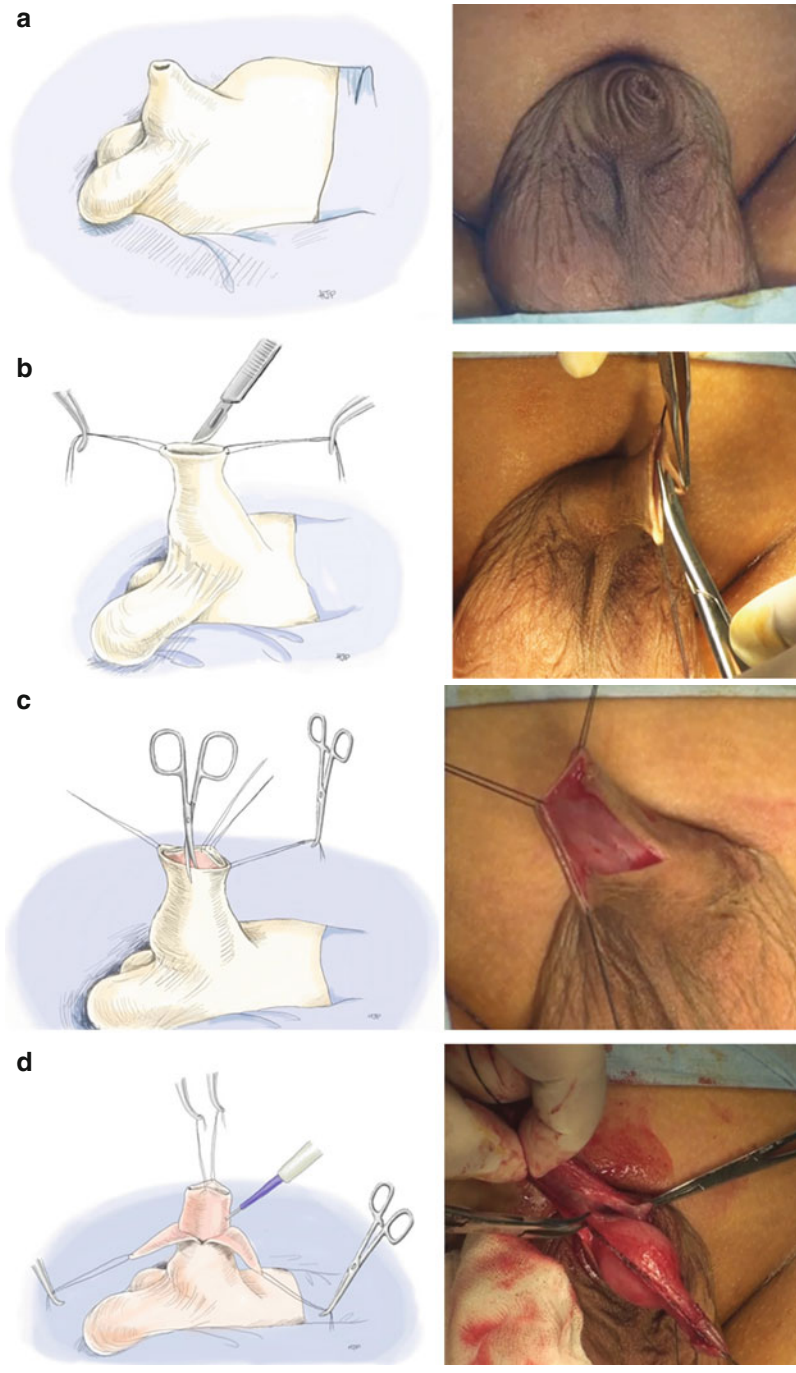

Fig. 30.5 The noble fixation technique (zigzag technique): (**a**) before operation, (**b**) two stay suture and incision or excision of phimotic ring, (**c**) dissection between inner and outer prepuce and laterally incisions of outer prepuce, (**d**, **e**) release of the fibrotic tissue and the distal attachment of the fundiform and/or suspensory ligaments attached to Buck's fascia, and also excess suprapubic fat is excised, (**f**) anchoring Buck's fascia to prepubic (2 points) and penoscrotal (2 points) skin, (**g**) incision of ventral and dorsal inner preputial skin, (**h**) suture of skin after trimming of the remained inner prepuce (Illustration by Dr. Sally Park and pictures from Dr. Taek Lee, Inha university hospital)

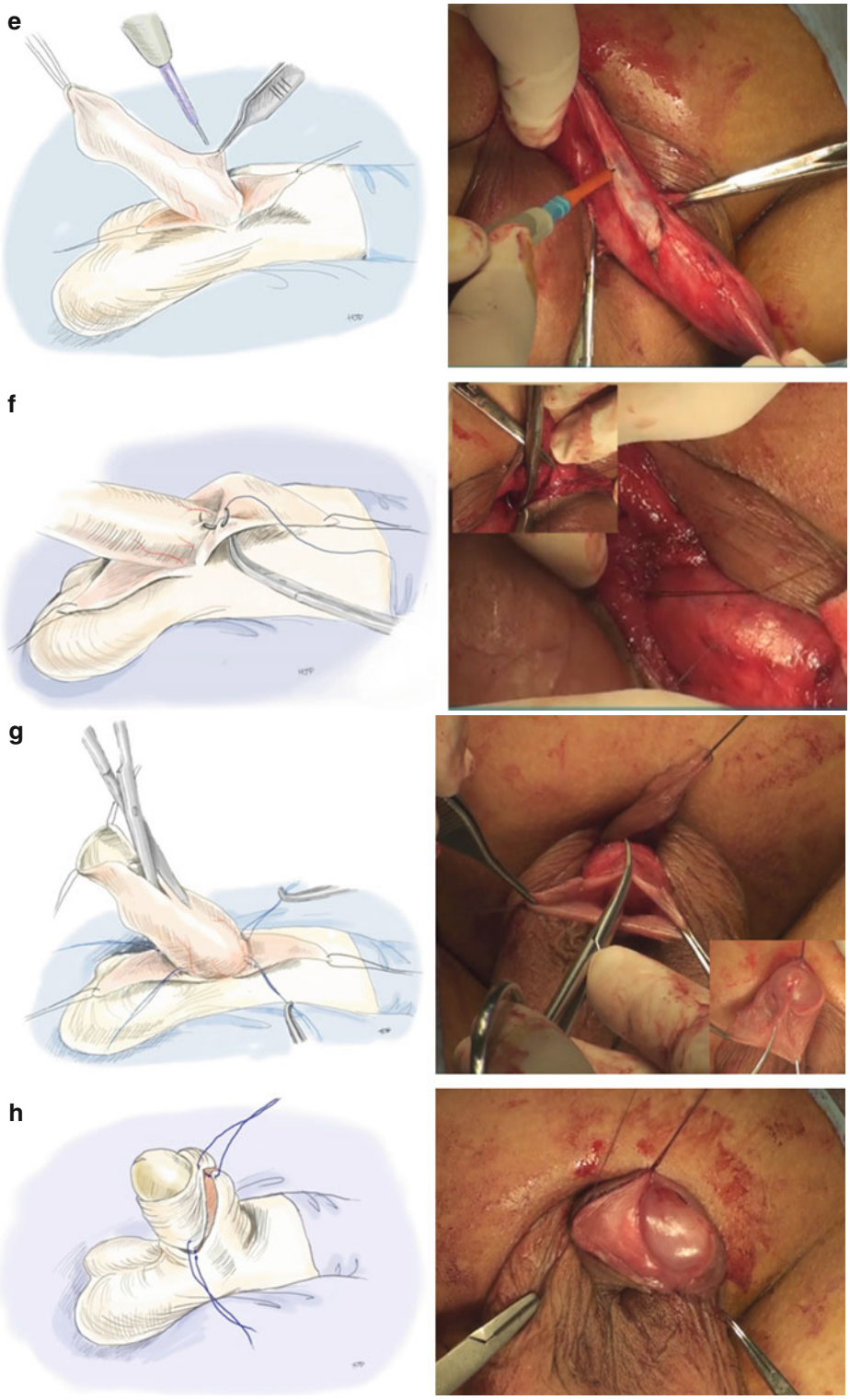

Fig. 30.5 (continued)

Conclusion

The buried penis is developed by a variety of etiologies and is corrected with variable and modified techniques. To correct with satisfactory result, the surgeon should have an exact knowledge about the etiologies, diagnosis, and therapeutic tools of this condition. Above all, in the surgical management, the surgeon should have an effort for minimizing complications, especially retraction of the penis again and postoperative edema through the procedures of the proper fixation of penis to skin and the trim of remnant inner preputial skin.

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Penoscrotal Transposition

31

Hyun Jun Park

Introduction

Penoscrotal transposition (PST) was reported for the first time by Appleby in 1923 [1]. PST is an extremely rare congenital malformation in which the scrotum is positioned superior and anterior to the penis. PST results from abnormal genital tubercle development around the 6th week of gestation [2]. It is associated with delay in the midline fusion of the urethral folds. Although the occurrence of the most reported cases of PST has been sporadic, other congenital anomalies such as hypospadias, chordee, and renal agenesis or dysplasia could be found in approximately 90 % of patients [3]. Gastrointestinal abnormalities, predominantly imperforate anus, were found in 30 % of cases [4]. Growth deficiency and mental retardation have also been noticed in 60 % of patients [5]. Differential diagnosis must include pseudohermaphroditism, penoscrotal hypospadias, micropenis, intrauterine penile amputation, and especially penile agenesis with a midline skin tag anterior to the anus [2].

Classification

Glenn and Anderson classified PST into bifid scrotum, incomplete or partial penoscrotal transpositions, complete penoscrotal transposition, or prepenile scrotum and ectopic scrotum [6]. However, Baky Fahmy et al. argued that Grenn and Anderon's classification does not distinguish levels of the midline creeping of the scrotal tissues, and bifid and ectopic scrotum seems to be separated from anomalous entities that are unrelated to PST [7]. He suggested a new classification of penoscrotal positional anomalies, which include PST and other anomalies into the following categories:

1. Penoscrotal transportation
   - Major transposition classified at:
   Complete (Extreme)
   Incomplete
   - Minor which are subdivided into:
   Bilateral (symmetrical)
   Unilateral
2. Central scrotalization of the median raphe
3. Wide penoscrotal distance or caudal penoscrotal transposition

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Surgery

Surgery of the more complex cases of PST is technically challenging for pediatric surgeons. It is usually performed between 12 and 18 months. As the size of the phallus and its potential to develop at puberty into a sexually satisfactory penis of paramount relevance when surgery is planned, many other characteristics and features of the anomaly should be taken in consideration when surgical intervention is decided [7].

Techniques

Various techniques have been suggested by many surgeons. Mcllvoy and Harris first performed surgery to move the penis into a more cranial position through a subcutaneous tunnel beneath the prepenile scrotum [8]. Forshall and Rickham used a different technique in two patients in whom the cranially located scrotal flaps were elevated, rotated medially and caudally, and sutured beneath the penis [9]. This method was also used by Glenn and Anderson (Fig. 31.1). Glenn-Anderson repair produced the best cosmetic results and lowest incidence of complications [6].

The technique was later modified by Dresner in 1982 [10]. Kolliqian in 2000 presented a radically divergent view of PST, stating that the penis and not the scrotum was malpositioned. They transferred the penis after straightening into a button hole designed in the skin of the mons pubis [11].

Singapore flap (Fig. 31.2). The majority of patients who had a Singapore flap underwent a prior urethroplasty elsewhere that failed. This procedure is a useful technique for patients who have large defects between the penis and scrotum. These flaps bring in well-vascularized tissue in patients who lack penile skin. Patients undergoing a Singapore flap repair should be counseled that they might require reoperation for release of penoscrotal tethering [3].

M-plasty was suggested by Manjunath and Venkatesh (Fig. 31.3) [12], which was modified as V-Y procedure.

Complications

The complications after surgery for PST included urethral and testicular injury, urinary fistula, flap necrosis, and penile edema. In the case of correction of hypospadias simultaneously, the complication rates were as high as 38–50 % [13–15]. Hence, to reduce the complications, hypospadias correction could be planned in the second stage [12].

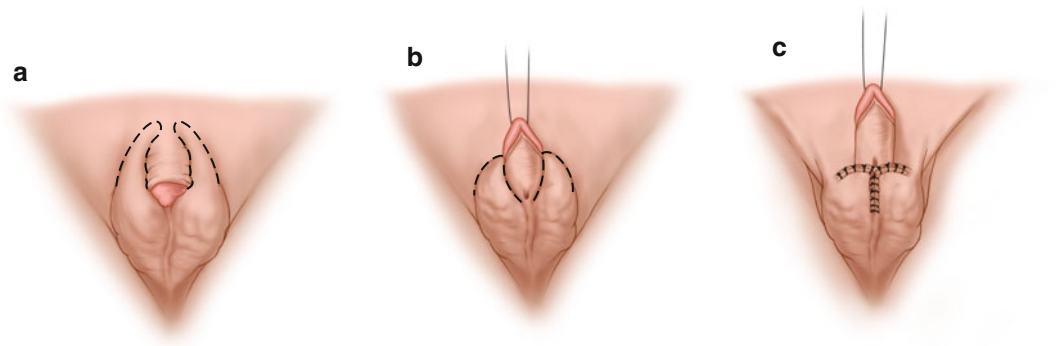

Fig. 31.1 (**a**) Hemi-circumferential incisions are made bilaterally around superior aspect of the scrotum and penis. (**b**) Incisions are carried on either side of the penis and connect in midline proximal to urethral meatus. (**c**) Reapproximation of scrotal flaps inferior to the penis

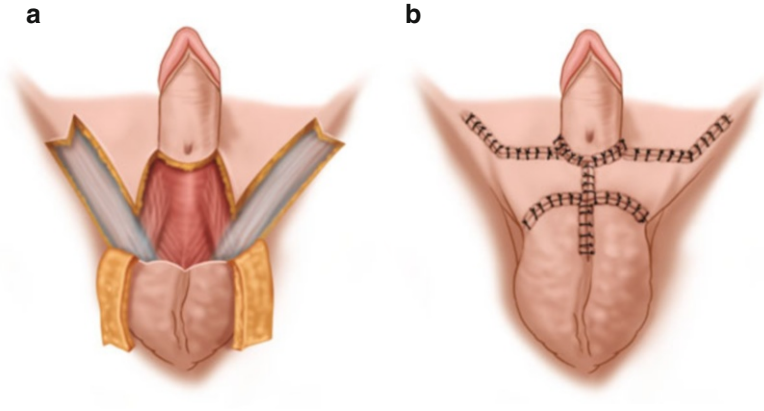

Fig. 31.2 (**a**) Axial skin flaps are designed from groin bilaterally. Flaps are thicker proximally because fascia is included to protect neurovascular pedicle. (**b**) Flaps are transposed medially and aligned in midline to correct penoscrotal fusion and tethering

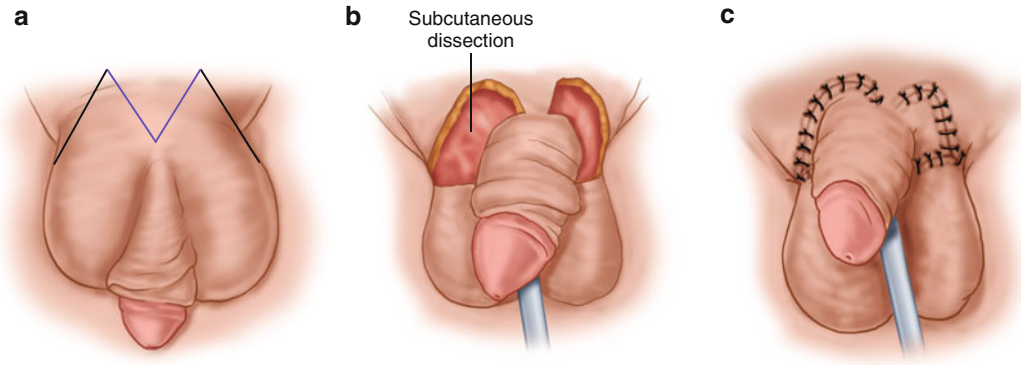

Fig. 31.3 (**a**) Inverted *V*-shaped incision was marked on the base of both scrotal half, with V joining in middle over the ventrum at the base of the penis making it *M* shape. (**b**) Dissection of both scrotal halves. (**c**) Scrotal halves were brought posterior to the penis while more caudal

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