Anaplastology
ISSN: 2161-1173

Golpanian et al., Anaplastology 2016, 5:2
DOI: 10.4172/2161-1173.1000159

Review Article Open Access

Phalloplasty and Urethral (Re)construction: A Chronological Timeline

Samuel Golpanian, Kenneth A Guler, Ling Tao, Priscila G Sanchez, Klara Sputova and Christopher J Salgado*

Division of Plastic Surgery, DeWitt Daughtry Family, University of Miami, Miami, FL, USA

Abstract

Since the first penile reconstruction in 1936, various techniques of phalloplasty and urethroplasty have been developed. These advancements have paralleled those in the field of plastic and reconstructive surgery and offer a complex patient population the opportunity of restoration of cosmetic and psychosexual function. The continuous evolution of these methods has resulted in constant improvement of the surgical techniques in use today. Here, we aim to describe a historical overview of phalloplasty and urethral (re)construction.

Keywords: Phalloplasty; Urethroplasty; Reconstruction; Transgender; Surgery

Introduction

Phalloplasty is a complex surgical task. Successful creation or restoration of the penis must meet certain cosmetic and functional thresholds. The ideal neophallus should be sensate, hairless, and similar in color to the surrounding skin. It should have an inconspicuous scar, maintain rigidity for sexual intercourse, and allow for micturition upon standing. A single-stage procedure with minimal donor-site morbidity is highly desirable, albeit the potential complications that may arise. Moreover, patient management should not only cover the surgery but also the psychosocial aspects of the treatment. Unfortunately, no single reconstructive method to date has successfully achieved all of these goals. Penile (re)construction may be required for a variety of reasons such as gender reassignment trauma, and cancer resection [1-4]. Less common applications for phalloplasty include the following: congenital defects, infectious diseases, as well as other pathologies such as hidradenitis suppurativa and lichen sclerosis [5-8]. Older reconstructive methods were lengthy and multi-staged. However, as the field of plastic surgery has progressed over the last century, so have the reconstructive techniques for (re)construction of the phallus and urethra. The introduction of microsurgical free flaps, in particular, has made a tremendous impact on the options available for phalloplasty.

In this article we present the methods of phalloplasty and urethral (re)construction that have been developed in chronological order, starting from the initial reports in the literature to the most recent and commonly used techniques.

Re(construction) of the Phallus

The first total penile reconstruction was described in 1936 by Bogoras [9], a Russian physician. He called this peniplastica totalis. He used abdominal wall to create a random pattern, tubed, pedicle flap and combined this with autologous rib cartilage graft to provide rigidity to the flap. This created the first penile reconstruction which could achieve successful coitus [10]. His technique required four stages, and did not create a competent neourethra or an aesthetically pleasing appearance. However, it was certainly innovative in nature. Reconstruction of the urethra within a flap remained a challenge until a decade later, in 1946, when Maltz [11] introduced a new step of inserting an outside-in tubular flap within the tubed abdominal pedicle graft. Gillies [12] improved and popularized this method by performing the first female-to-male reassignment procedure on British physician, Laurence Michael Dillon. Although this method involved [13] separate operative steps, it remained the standard technique for female-to-male gender reassignment over the next 40 years. Various fasciocutaneous and extended pedicle island flaps were also developed during this time. Nonetheless, they continued to have suboptimal functional and aesthetic results due to their significant limitations in sensory recovery primarily [10,13,14].

Throughout the 1970's other innovations were introduced in the field of penile reconstruction. In 1971, Kaplan et al. [15] developed a method that provided sensation to the neophallus. Their method involved using a pedicled medial thigh flap, based on the femoral branches of the genitofemoral nerve, to create the penile shaft and a turned-in flap from the median raphe of the scrotum to construct the urethra. This technique was initially used for patients who underwent penile amputation due to penile cancer. In 1972, Orticochea [16], a Colombian physician, first used a pedicled tube flap involving the gracilis muscle to provide an erection in patients who required reconstruction secondary to trauma and/or surgical ablation. In addition, the obturator nerve, which supplies sensation to the inner aspect of the thigh, was included and allowed the neophallus to experience erogenous, thermal, pain, and tactile sensations. A neourethra was also created. Patients reported satisfactory results in sexual performance and were even able to achieve orgasm. Despite these benefits, this technique consisted of five stages and included complications such as urethral fistulas and stenosis in addition to muscle-related problems with the gracilis muscle.

That same year, Mc Gregor et al. [17] developed the groin flap which was later adapted by Puckett, et al. [18] in 1976 for penile reconstruction, including a Scott penile inflation device to produce an erection. Previously, silicone rubber rods, bone, or cartilage were used to provide penile rigidity, but were found to erode through the soft tissue, as the neophallus takes some time to become sensate (9-12 months). Moreover, the constant rigidity served as a source of embarrassment to the patient [19] and led to the creation of the Scott prosthesis. Initially, the development of a constricting scar around the

***Corresponding author:** Christopher J Salgado MD, Professor of Surgery, Division of Plastic, Aesthetic & Reconstructive Surgery, Clinical Research Building, 1120 NW 14th Street, 4th Floor, Miami, FL 33136, USA, Tel: 305-243-4500; Fax: 305-243-4535; E-mail: christophersalgado@med.miami.edu

Received: August 01, 2016; **Accepted:** September 13, 2016; **Published:** September 20, 2016

Citation: Golpanian S, Guler KA, Tao L, Sanchez PG, Sputova K, et al. (2016) Phalloplasty and Urethral (Re)construction: A Chronological Timeline. Anaplastology 5: 159. doi: 10.4172/2161-1173.1000159

inflation cylinder in the penis posed a problem. However, this was easily resolved by instructing the patients to only partially inflate the cylinders and to massage the neophallus during the healing phase.

In 1978, Horton et al. [20] introduced the first single-stage total penile reconstruction using bilateral gracilis muscle flaps for the penile shaft and a full thickness skin graft for the urethra. In addition to successfully completing penile and urethral reconstruction with minimal morbidity, they also achieved aesthetically favorable results. Advances in microsurgery over the next decade led to the development of the first free flap phalloplasty in 1982 by Song et al. [21] Puckett et al. [22] also employed the free flap phalloplasty with a successful outcome in two of their patients, while the third required a staged procedure secondary to flap loss. In 1984, Chang et al. [23] were the first to report the tube-within-a-tube radial forearm free flap (RFFF). This flap provided soft, hairless forearm skin, with uniformly thin subcutaneous tissue and a long vascular pedicle. They used autologous rib cartilage to provide rigidity since they believed that acrylic or silicone implants were prone to erode through the soft tissue after several years. Seven of their patients had successful outcomes, while one patient developed a fistula near the urethral anastomosis that was later corrected.

In 1988, Biemer [24] improved upon the RFFP by introducing the radial forearm osteocutaneous flap which provides more rigidity to the neophallus. This is still one of the most widely used techniques for penile reconstruction today. Sadove et al. [25] later reported on the free sensate osteofasciocutaneous fibula flap in biological males with traumatic amputations as well as female-to-male transsexuals. This method offers intrinsic rigidity (due to the larger volume of bone), superior donor-site location, and sensation from the lateral sural cutaneous nerve, and a long vascular pedicle enabling an end-to-side anastomosis of the flap to the femoral artery. Interestingly, both types of patients reported the ability to achieve orgasm, yet sensation of the neophallus was only described in half the transsexuals. However, the authors claimed that little correlation could be made between extent of sensation and ability to reach orgasm. Furthermore, it has been reported to have high patient satisfaction since it is easier to hide the donor-site on the lower extremity than on the upper extremity [26]. Still, sensation of the flap is dependent solely on the superficial peroneal nerve.

At the start of the 21st century, Santanelli et al. [27] were the first to report the use of the islanded pedicled fasciae lata flap based on the lateral circumflex femoral artery. They performed this flap on five female-to-male transsexuals and suggested that this mode of reconstruction left a less conspicuous donor-site. Despite its small dimensions, it is a safe option and provides sensation.

In 2006, Felici et al. [28] reported a new phalloplasty technique using the free anterolateral thigh (ALT) flap. Proponents of this flap proposed that it often avoids the common complications and problems encountered with previous techniques. The authors showed promising results and found that the ALT flap was sensate and could easily incorporate an inflatable implant. The ALT flap also had very low donor-site morbidity and the scar was easily concealed. It is limited, however, by the anatomic variability of the perforator vessels. Also, the additional requirement of a skin graft to cover the thigh donor-site has made it unacceptable to many patients [10], particularly patients who are obese. Koshima et al. [29] described the bilateral superficial circumflex iliac artery perforator flaps as another alternative for penile reconstruction. Advantages of this technique include a single-stage procedure, minimal donor-site morbidity with a concealed donor-site scar, and the ability to create a long urethra of up to 22 cm in length without developing complications, such as fistulas and strictures. However, poor sensory recovery remains a disadvantage of the ALT flap.

In 2007, Perovic et al. [30] reported on the use of the latissimus dorsi free flap for phalloplasty in an effort to counter previous limitations encountered with other reconstructive forms. This flap is easily elevated and has a very long pedicle allowing for an easier and direct anastomosis. There is also minimal donor-site functional weakness and scarring. The authors reported an 80% patient satisfaction rate with no flap loss or partial skin necrosis. The latissimus dorsi free flap also provides sufficient length to create an adult sized penis size in prepubertal children optimizing results and ensuring a better psychosexual development [31]. In the same year, Wang et al. [32] and Yang et al. [33] reported the use of a free scapular skin flap for penile reconstruction, although this was first described in 1997 by Rohrich et al. [34] as a combined reconstruction with a latissimus dorsi free flap for penile and perineal reconstruction. Due to the scapula's complex anatomical configuration, they preferred to use a penile implant to provide adequate rigidity. Both investigators achieved favorable aesthetic and functional results and considered this an ideal method of reconstruction [35].

Lee et al. [36] in 2008, described a single flap technique for total penile reconstruction using the pedicled ALT flap. The main advantage was that their method did not require microsurgery. Furthermore, this flap was shown to provide greater bulk and better skin color matching. The authors suggested that if the anterolateral thigh was too thick then the next best option would be to perform a RFFF. That same year, Lumen et al. [37] presented comparative results using the RFFF and the pedicled ALT flap for penile reconstruction. Their cohort consisted of 11 patients, seven of whom were treated with RFFF and four with a pedicled ALT flap due to contraindications to free flap creation (i.e. variable pelvic anatomy and vasculature) or patient preference. They found that sensitivity was markedly reduced with the ALT flap, which was expected since only one nerve innervates this area (lateral femoral cutaneous nerve). Today, the radial forearm free flap remains the most common form of phalloplasty. A search of the literature has demonstrated various experiences among different surgeons and institutions using a multitude of reconstructive techniques (Table 1). Our group recently performed a successful RFFF without bone on a 62 year-old African American male, with hypertension and type 2 diabetes, who was 8 months post-penectomy for penile squamous cell carcinoma. There were no post-operative complications or donor-site morbidity (Figure 1). This technique's reliability for producing favorable aesthetic results, low donor-site morbidity, and outstanding erogenous sensitivity surpasses other means of reconstruction [38]. In cases where there are contraindications to free flap use or insufficient expertise and confidence, other available reconstructive methods [27-29] can be employed.

(Re)construction of the Pars Pendulans and Pars Fixa

The penis plays an important physiological role in both the genitourinary and reproductive systems. Due to its intricate anatomy and function, (re)construction poses a great challenge. In addition to creating or reconstructing a phallus that is aesthetically pleasing in shape and size, erogenously sensate, and sufficiently rigid to accomplish coitus, total penile (re)construction should also provide the patient with the ability to urinate through the urethra from a standing position [38-41].

Successful phalloplasty requires (re)construction of the pars

Flap type	Author(s), Ref no.	Total cases (n)	Total complications (n)	Complication-type number (n)
Radial forearm free (RFFF)	Meyer et al. [57]	1	0	none
	Matti et al.	5	5	total flap loss [3]; fistula [2]
	Cheng et al.	93	13	Total necrosis [1], partial necrosis [6], fistula [3], stricture [3]
	De Fontaine et al.	1	0	None
	Monstrey et al. [38]	81	87	partial flap failure [2], total flap failure [1], PE* [2], anastomotic re-exploration [16], partial skin graft failure [2], poor wound healing [18], nerve compression [2], fistulas [17], structures [26], urinary complication [1]
	Selvaggi et al. [2]	125	15	donor-site hematoma [1], incomplete graft take [6], prolonged hand edema [7] burn on grafted hand due to temperature insensitivity [1]
	Rashid et al.	36	18	flap loss [1], partial flap necrosis [1], fistula [8], stricture [6], urinary obstruction due to intra-urethral hair growth [2]
	Leriche et al.	56	43	flap loss [3], venous thrombosis [1], arterial ischemia [1], infection [5], distal necrosis [2], hematoma [2], fistula [15], urinary retention [3], prosthesis change [8], prosthesis explantation [3]
	Timsit et al.	6	3	stricture [2], prosthesis extrusion and infection sphincter [1]
	Garaffa et al. [4]	15	21	phallic partial skin necrosis [20], contracture [2], metal structure [3], anastomotic stricture [1], urethral fistula [5], prosthesis infection [1], donor-site incomplete graft take [2], contracture [2], loss of sensation [2], hand edema [1]
	Monstrey et al. [37]	287	304	total flap loss [2], partial necrosis [21], anastomotic revision [34], fistula [51], stricture [21], fistula/ stricture requiring urethroplasty [52], PE [3], donor-site regrafting [2], nerve compression [2], delayed wound healing [32], prosthesis revision [58], unable to perform sexual intercourse [26]
	Caenegem et al.	44	0	None
	Massanyi et al.	10	7	partial flap loss [1], arterial thrombosis [1], neuroma [1], stricture [1], prosthesis infection [1], prosthesis erosion [2]
	Garaffa et al. [39]	16	17	arterial thrombosis [2], partial flap loss [1], incomplete graft take [3], fistula [6], stricture [2], penile prosthesis infection [2], inadequate penile prosthesis length [1]
Modified RFFF	Semple et al.	2	1	required debulking [1]
Radial forearm osteocutaneous	Fang et al. [14]	22	30	partial flap loss [1], fistula [14], urethral stricture [3], partial abdominal flap necrosis [2], donor-site radius bone fracture [1], decrease in pinch/grip power [2], LROM** of wrist [2], 1st dorsal web paresthesia [5]
	Kim et al. [53]	40	16	fistula [8], wound infection [2], partial flap loss [3], total flap loss [1], delayed healing donor-site [2]
Anterolateral thigh (ALT)	Cheng et al.	10	0	None
	Felici et al. [28]	6	0	None
	Rubino et al.	1	0	None
	Lee et al. [36]	2	2	fistula [2]
	Spyriounis et al.	1	1	required debulking
	Hasegawa et al.	1	0	None
Modified ALT	Morrison et al. [45]	1	5	vascular congestion, partial flap necrosis, fistula, groin cellulitis, meatal stenosis
Osteocutaneous free fibula	Sadove et al. [25]	4	4	fistula [2], delayed healing [1], required debulking [1]
	Hage et al. [41]	1	1	urethral stenosis [1]
	Capelouto et al.	1	0	None
	Sengezer et al. [25]	18	3	flap loss [1], metal stricture [1], urethral stricture [1]
Pedicled island groin	Puckett et al. [18]	1	0	None
	Perovic et al. [13]	24	5	partial flap necrosis [2], fistula [2], urethral stenosis [1]
Latissimus dorsi (LD)	Djordjevic et al. [31]	16	5	fistula [2] scarred donor site [3]

	Perovic et al. [30]	8	7	fistula [3], scarred donor site [4]
	Vesely et al.	22	14	hematoma [7], vascular thrombosis [2], partial flap necrosis [1], excessive neophallus edema [3], skin graft loss [1]
Scapular (Sc)	Wang et al. [32]	15	1	venous thrombosis [1]
	Yang et al. [33]	20	0	None
	Dong et al.	1	1	urethral fistula [1]
Combined LD-Sc	Rohrich et al. [34]	1	1	prosthesis erosion [1]
Deep inferior epigastric perforator (DIEP)	Davies et al.	4	0	None
Superficial inferior epigastric artery (SIEA)	Cheng et al.	26	4	fistula [3], stricture [1]
Superficial circumflex artery	Cheng et al.	4	1	fistula [1]
Tensor fasciae latae (TFL)	Santanelli et al. [27]	5	1	partial flap necrosis [1]
Free lateral upper arm with bladder graft	Hage et al. [42]	1	2	meatal stenosis [1], bladder spasm [1]
Free lateral upper arm	Khouri et al. [58]	3	0	None

Table 1: Phalloplasty Flaps and Associated Complications.

pendulans and pars fixa [42]. Historically, there have been numerous attempts to recreate the urethra and reduce the high incidence of complications such as fistulas and strictures [42]. Urological complication rates in phallic (re)construction have been reported to be between 50% and 80% [24]. Table 2 displays the various complications associated with urethroplasty. As expected, efforts continue to improve upon existing surgical techniques. Since the creation or reconstruction of both the fixed portion and a movable portion of the penis is required with consideration of multiple angles of orientation, major problems inevitably arise. The ability to cover the urethral anastomosis with bulky, well-vascularized tissues is crucial for preventing fistula formation [25]. Furthermore, while some surgeons have developed combined or staged procedures for phallus and urethral (re)construction, others have also reported on their efforts solely to reconstruct the urethra [43,44]. Currently, the pars pendulans is commonly constructed via prelamination, which helps decrease the incidence of urethrocutaneous fistulas [10]. The RFFF is a commonly employed flap for urethral prelamination [38]. This flap offers a consistent, reliable vascular pedicle and pliable skin that permits shaping and flexibility for design [45]. We recently reconstructed a penis in a 24 year-old transgender male using a radial forearm osteocutaneous free flap with mucosal prelamination (Figure 2a). Stage I prelamination can be performed using a radial forearm flap with vaginal mucosa, buccal mucosa, and skin graft (if needed) for the neourethra (Figure 2b). However, use of this flap with sacrifice of a major artery to the hand has been associated with donor-site morbidity 2, [46-48]. Therefore, some authors have recommended using the ALT flap to avoid these complications [49]. Despite technical advances in microsurgery, urologic complications rates remain as high as 40%, as described by Hoebeke and Monstrey in a series of 287 patients [50]. Reconstructing the pars fixa is for lengthening purposes and, in turn, avoids further complications. For a successful phalloplasty, lengthening of the short female urethra is an essential step in order to perform an intact and secure anastomosis. Furthermore, many authors [51-53] suggest advancing the neourethra more anteriorly, which can be achieved by reconstruction of this portion [42]. Tables 3 and 4 display the multiple techniques and flap types used over time for (re) construction of the pars pendulans and pars fixa, respectively.

Phalloplasty in the Pediatric Population

In 1982, Tank et al. [54] encountered eight cases of penile amputation and performed penile reconstruction in two children with satisfactory cosmetic and functional results. Over a decade later,

Figure 1: Radial Forearm Free Flap (RFFF) Reconstruction for Penile Cancer. (a) Status post penectomy for penile squamous cell carcinoma. (b) 7 months post-phalloplasty with RFFF. Patient is currently awaiting implant placement. (c) Donor site with healed skin graft.

Perovic [13] reported the use of the extended pedicle island groin flap for phalloplasty in children and adolescents. In 2006, Djordjevic et al. [31] described the use of the musculocutaneous latissimus dorsi free transfer flap for total phalloplasty in prepubertal children to prevent psychological trauma from body dysmporphia. The authors' results demonstrated phallic sizes ranging from 13-16 cm in length, no flap necrosis, acceptable donor-site scarring and, importantly, an overall improvement of psychological well-being. Phalloplasty in the pediatric population presents is more challenging than in adults. The most accepted recommended time for (re)construction in the pediatric population is between 10 – 14 years of age 13. The inability for exponential growth of a pediatric reconstructed phallus or constructed neophallus (compared to testosterone-induced growth of a normal penis) and the psychological impact related to genital inadequacy are of highest concern. Common methods for phallus reconstruction, such as the fasciocutaneous forearm flap, are more likely to contract than muscle-based grafts. This is due to connective tissue being more prone to contraction compared to well-vascularized, denervated muscle [55]. Therefore, prepubertal phallus reconstruction must reflect an adult penis size to reduce the chances of genital inadequacy and subsequent psychological stress. All these factors should be discussed with both the parents and child prior to surgery. Although gender identity is considered to develop by 18 months old, construction of a neophallus is not commonly preformed in transgendered patients until the age of 18. However, in cases of amibiguous genitalia, the patient may have a female phenotype with a male genotype, and surgical construction to

Technique with/without flap	Author(s), Ref.	Total cases (n)	Total complications (n)	Total complication rate (%)	Complication-type number (n)
Radial forearm free (RFFF)	Morrison et al. [45]	7	3	43	superficial shaft skin necrosis [1][14%]; recurrent narrowing [2]
RFFF with full-thickness skin graft (FTSG)	Levine et al.	1	1	100	re-stricture
RFFF with split-thickness skin graft (STSG)	Levine et al.	3	2	67	graft failure [2]
RFFF with labial/vaginal flap	Levine et al.	1	1	100	re-stricture
	Rohrmann et al.	16	11	69	fistula and/or stricture [vaginal, 11]
		5	3	60	fistula and/or stricture [labial, 3; 60]
	Garaffa et al. [43]	27	8	30	flap ischemia [2], abscess [2], hematoma [1], urethral stricture [1], fistula [2]
RFFF with bladder/buccal mucosa graft	Levine et al.	1	1	100	re-stricture (bladder)
		3	0	0	none (buccal)
Radial forearm osteocutaneous with labial/ vaginal flap	Kim et al. [53]	32	8	25	flap loss [1], fistula [7]
Bladder flap	Edgerton et al.	6	0	0	None
Buccal mucosa	Bürger et al.	6	4	67	fistula [3], stenosis [1]
Combined labial/bladder mucosa free graft	Dessanti et al.	12	5	42	fistula [1], stenosis [4]
Labial flap with buccal mucosa	Djordjevic et al. [55]	38	3	8	fistula [2], urethral erosion [1]
Peritoneal flap	Hage et al. [51]	1	1	100	flap loss
Superficial circumflex iliac artery	Yoo et al. [44]	1	0	0	none

Table 2: Urethral Reconstruction for Phalloplasty and Associated Complications.

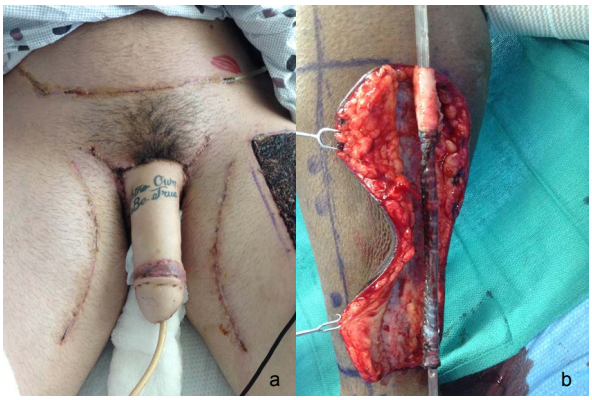

Figure 2: Female-to-Male Transgender Phalloplasty with Mucosal Prelamination, (a) 1 month post-operative image of transgendered male phallus reconstructed with prelaminated mucosa radial forearm osteocutaneous free flap, (b) Stage I prelamination utilizing fibula flap with proximal vaginal mucosa and skin graft for neourethral reconstruction.

their genotype may be recommended [3].

Conclusion

Despite the great technical advances since the initial complete penile reconstruction was performed, reconstructive outcomes are still suboptimal. Phallic and urethral (re)construction require a multidisciplinary approach by the plastic reconstructive surgeon and urologist in order to achieve acceptable results. Currently, there is a lack of standard outcome measures to properly evaluate the most optimal reconstructive method. Previously reported results and outcomes have been based on a broad spectrum of patients often as little as one patient case reports and surgeon experience, thus making the reports even more subjective. Further, the complications have not been stratified according to severity. Important outcome measures for phalloplasty are erectile capacity and fistula occurrence. With microsurgical advances, flap transfer survival is no longer the most common challenge, but rather fistula occurrence.

Primary outcomes in transgender patients should be judged on assessment of their level of gender dysphoria. The Utrecht Gender Dysphoria Scale (UGDS) [56] and the Gender Identity/Gender Dysphoria Questionnaire for Adolescents and Adults (GIDYQ-AA) [57] are useful instruments in measuring gender dysphoria pre- and post-reconstruction. Although both tools evaluate gender dysphoria, differences exist between what aspects of gender dysphoria they assess. While the UGDS focuses more on physical aspects and gender role, the GIDYQ-AA emphasizes social and more subjective gender dysphoria issues. Therefore, future studies on phalloplasty outcomes should incorporate multiple scales to accurately encapsulate patient satisfaction and benefit. Secondary outcomes should include physical and sexual function as well as morbidity. Key complications include partial or total flap loss, anorgasmia, urethral fistulas, infections, and wound separations. Short-term studies can include outcome measures pre- and post-reconstruction, while long-term studies can assess patient outcomes post-reconstruction. Since patients can potentially undergo up to 6 surgeries within the first year after phalloplasty [58], it seems appropriate that the time points post-reconstruction should be monthly and either biannually or annually thereafter. Because penile reconstruction is oftentimes met with complications requiring multiple revisions, long-term studies may be more informative as they follow the patient over time. A thorough and multi-disciplinary pre-operative evaluation is necessary before surgery to maximize outcomes. Studies may benefit from correlating pre-operative planning with post-operative outcomes, which will help guide surgeons' decision making and to reduce poor outcomes.

Recent developments in tissue bioengineering [59] and stem cell

Technique/Flap Type	Author(s), Ref.no	Year
1. Tube-within-tube	Maltz et al [11]	1946
	Gillies [12]	1948
	Gillies and Millard [12]	1957
2.Segment of ileum within abdominal	Hoopes	1969
tubular pedicled flap	Edgerton and Meyer	1973
3. Anterior vaginal wall	Hoopes	1969
	Edgerton and Meyer	1973
4."Chinese roll" forearm flap	Chang and Hwang	1984
5. Bladder flap	Edgerton	1984
6. Dorsalis pedis within groin flap	Biemer [24]	1982
7. Tubular RFFF within deep inferior epigastric flap	Davies and Matti	1988
8. Tubular RFF flap within outside-in abdominal pedicled tube flap with skin grafting	Laube	1989
9. Peritoneal free flap	Winters	1997
10. Prelaminated osteocutaneous fibula flap	Capelouto et al	1997
11. Prelaminated lateral arm free flap	Khouri et al [58]	1998
12. Prelaminated ALT flap	Ozkan and Ozkan	2009
13. Prelaminated RFF flap	Monstrey et al [40]	2009

Table 3: Pars Pendulans Urethral (Re)construction for Phalloplasty.

Technique/Flap Type	Author(s), Ref.no	Year
1. Bladder and buccal mucosa grafts	Humby and Higgins	1941
2. Tube-in-a-tube with incorporated skin tube	Gillies and Millard	1957
3. Anterior vaginal flap	Thompson	1971
	Puckett and Montie	1978
	Hage et al [41]	1993
4. Vaginal mucosa	Horton et al.	1977
5. Bladder mucosal grafts	Levine et al.	1989
	Pryor and Gill	1991
	Burger et al.	1992
	Dessanti	1992
6. Labial and buccal mucosa grafts	Dessanti et al.	1995
7. Labia minor flap	Djordjevic et al [30]	2009
8. Labial ring flap*	Takamatsu	2009

*Uses all of the labia minora skin incorporated with the anterior vaginal flap for urethral lengthening while releasing the clitoral chordee

Table 4: Pars Fixa (Re)construction for Phalloplasty.

therapy [60] may play a future role in improving upon previously used methods or may offer entirely novel techniques for modern phalloplasty. Early reports of penile transplantation, describing its feasibility, technical aspects, and outcomes have been made [61-63]. Nevertheless, ethical issues related to both the donor and recipients remain a concern [64]. Finally, the ultimate therapeutic success depends on the psychosocial aspects of treatment as well. As such, it is the duty of the reconstructive surgeon to use methods that will create an aesthetic and functional phallus and urethra while managing the expectations of their patients.

Conflicts of Interest Statement: None of the authors have any financial disclosures.

References

1. Pryor JP, Gill H (1991) Surgical considerations in 29 female to male transsexual patients. Gender Dyphoria, 1: 44-49.
2. Selvaggi G, Monstrey S, Hoebeke P, Ceulemans P, Van Landuyt K, et al (2006) Donor-site morbidity of the radial forearm free flap after 125 phalloplasties in gender identity disorder. Plast Reconstr Surg 118: 1171-1177.
3. Ochoa B (1998) Trauma of the external genitalia in children: Amputation of the penis and emasculation. J Urol 160: 1116-1119.
4. Garaffa G, Raheem AA, Christopher NA, Ralph DJ (2009) Total phallic reconstruction after penile amputation for carcinoma. BJU Int 104: 852-856.
5. Bluebond-Langner R, Redett RJ (2011) Phalloplasty in complete aphallia and ambiguous genitalia. Semin Plast Surg 25: 196-205.
6. Ferreira PC, Reis JC, Amarante JM, Silva AC, Pinho CJ, et al (2007) Fournier's gangrene: A review of 43 reconstructive cases. Plast Reconstr Surg 119: 175-184.
7. Rieger UM, Erba P, Pierer G, Kalbermatten DF (2009) Hidradenitis suppurativa of the groin treated by radical excision and defect closure by medial thigh lift: Aesthetic surgery meets reconstructive surgery. J Plast Reconstr Aesthet Surg JPRAS 62: 1355-1360.
8. Pugliese JM, Morey AF, Peterson AC (2007) Lichen sclerosus: Review of the literature and current recommendations for management. J Urol 178: 2268-2276.
9. Bogoras N (1936) Uber die volle plastische wieder herstellung eines zum koitus fahigen penis. Zentralbl Chir 63: 1271-1276.
10. Salgado CJ, Garrido DE, Eidelson SA, Mardini S, Sinha V (2014) Reconstruction of the penis. In Aesthetic and Functional Surgery of the Genitalia 255-282.
11. Maltz M (1946) Maltz reparative technique for the penis. Evolution of plastic surgery 278-279.
12. Gillies H (1948) Congenital absence of the penis. Br J Plast Surg1: 8-28

13. Perovic S (1995) Phalloplasty in children and adolescents using the extended pedicle island groin flap. J Urol 154: 848-853.

14. Fang RH, Kao YS, Ma S, Lin JT (1999) Phalloplasty in female-to-male transsexuals using free radial osteocutaneous flap: A series of 22 cases. Br J Plast Surg 52: 217-222.

15. Kaplan I (1971) A rapid method for constructing a functional sensitive penis. Br J Plast Surg 24: 342-344.

16. Orticochea M (1972) A new method of total reconstruction of the penis. Br J Plast Surg 25: 347-366.

17. McGregor IA, Jackson IT (1972) The groin flap. Br J Plast Surg 25: 3-16.

18. Puckett CL, Montie JE (1978) Construction of male genitalia in the transsexual, using a tubed groin flap for the penis and a hydraulic inflation device. Plast Reconstr Surg 61: 523-530.

19. Salgado CJ, Rampazzo A, Xu E, Chen HC (2008) Treatment of dyspareunia by creation of a pseudo joint in rigid bone following total penile reconstruction with fibular osteocutaneous flap. J Sex Med 5: 2947-2950.

20. Hester TR, Hill HL, Jurkiewicz MJ (1978) One-stage reconstruction of the penis. Br J Plast Surg 31: 279-285.

21. Song R, Gao Y, Song Y, Yu Y, Song Y (1982) The forearm flap. Clin Plast Surg 9: 21-26.

22. Puckett CL, Reinisch JF, Montie JE, (1982) Free flap phalloplasty. J Urol 128: 294-297.

23. Chang TS, Hwang WY (1984) Forearm flap in one-stage reconstruction of the penis. Plast Reconstr Surg 74: 251-258.

24. Biemer E (1988) Penile construction by the radial arm flap. Clin Plast Surg 15: 425-430.

25. Sadove RC, Sengezer M, McRoberts JW, Wells MD (1993) One-stage total penile reconstruction with a free sensate osteocutaneous fibula flap. Plast Reconstr Surg 92: 1314-1323.

26. Schaff J, Papadopulos NA (2009) A new protocol for complete phalloplasty with free sensate and prelaminated osteofasciocutaneous flaps: Experience in 37 patients. Microsurg 29: 413-419.

27. Santanelli F, Scuderi N (2000) Neophalloplasty in female-to-male transsexuals with the island tensor fasciae latae flap. Plast Reconstr Surg 105: 1990-1996.

28. Felici N, Felici A (2006) A new phalloplasty technique: The free anterolateral thigh flap phalloplasty. J Plast Reconstr Aesthet Surg JPRAS 59: 153-157.

29. Koshima I, Nanba Y, Nagai A, Nakatsuka M, Sato T, et al (2006) Penile reconstruction with bilateral superficial circumflex iliac artery perforator (scip) flaps. J Reconstr Microsurg 22: 137-142.

30. Perovic SV, Djinovic R, Bumbasirevic M, Djordjevic M, Vukovic P (2007) Total phalloplasty using a musculocutaneous latissimus dorsi flap. BJU Int 100: 899-905.

31. Djordjevic ML, Bumbasirevic MZ, Vukovic PM, Sansalone S, Perovic SV (2006) Musculocutaneous latissimus dorsi free transfer flap for total phalloplasty in children. J Pediatr Urol 2: 333-339.

32. Wang H, Li SK, Yang MY, Li YQ, Li Q (2007) A free scapular skin flap for penile reconstruction. J Plast Reconstr Aesthet Surg JPRAS 60: 1200-1203.

33. Yang M, Zhao M, Li S, Li Y (2007) Penile reconstruction by the free scapular flap and malleable penis prosthesis. Ann Plast Surg 59: 95-101.

34. Rohrich RJ, Allen T, Lester F, Young JP, Katz SL (1997) Simultaneous penis and perineum reconstruction using a combined latissimus dorsi-scapular free flap with intraoperative penile skin expansion. Plast Reconstr Surg 99: 1138-1141.

35. Babaei A, Safarinejad MR, Farrokhi F, Iran-Pour E (2010) Penile reconstruction: Evaluation of the most accepted techniques. J Urol 7: 71-78.

36. Lee GK, Lim AF, Bird ET (2009) A novel single-flap technique for total penile reconstruction: The pedicled anterolateral thigh flap. Plast Reconstr Surg 124: 163-166.

37. Lumen N, Monstrey S, Ceulemans P, van Laecke E, Hoebeke P(2008) Reconstructive surgery for severe penile inadequacy: Phalloplasty with a free radial forearm flap or a pedicled anterolateral thigh flap. Adv Urol 2008: 704343.

38. Monstrey S, Hoebeke P, Dhont M, Selvaggi G, Hamdi M (2005) Radial forearm phalloplasty: A review of 81 cases. Eur J Plast Surg 28: 206-212.

39. Garaffa G, Spilotros M, Christopher NA, Ralph DJ (2014) Total phallic reconstruction using radial artery based forearm free flap phalloplasty in patients with epispadias-exstrophy complex. J Urol 192: 814-820.

40. Salgado CJ, Chim H, Tang JC, Monstrey SJ, Mardini S (2011) Penile reconstruction. Semin Plast Surg 25: 221-228.

41. Hage JJ, Bout CA, Bloem JJ, Megens JA (1993) Phalloplasty in female-to-male transsexuals: What do our patients ask for? Ann Plast Surg 30: 323-326.

42. Hage JJ, Bloem JJ, Suliman HM (1993) Review of the literature on techniques for phalloplasty with emphasis on the applicability in female-to-male transsexuals. J Urol 150: 1093-1098.

43. Garaffa G, Ralph DJ, Christopher N (2010) Total urethral construction with the radial artery-based forearm free flap in the transsexual. BJU Int 106: 1206-1210.

44. Yoo KW, Shin HW, Lee HK (2012) A case of urethral reconstruction using a superficial circumflex iliac artery. Arch Plast Surg 39: 253-256.

45. Morrison WA, Webster HR, Kumta S (1996) Urethral reconstruction using the radial artery forearm free flap: Conventional and prefabricated. Plast Reconstr Surg 97: 413-419.

46. Boorman JG, Brown JA, Sykes PJ (1987) Morbidity in the forearm flap donor arm. Br J Plast Surg 40: 207-212.

47. Ozkan O, Coskunfirat OK, Dikici MB, Ozgentas HE (2005) A rare and serious complication of the radial forearm flap donor site: Osteomyelitis of the radius. J Reconstr Microsurg 21: 293-296.

48. Richardson D, Fisher SE, Vaughan ED, Brown JS (1997) Radial forearm flap donor-site complications and morbidity: A prospective study. Plast Reconstr Surg 99: 109-115.

49. Dabernig J (2006) Neo-urethra preformation in free anterolateral thigh flap. J Plast Reconstr Aesthete Surg JPRAS 59: 779-780.

50. Hoebeke P, Selvaggi G, Ceulemans P, De Cuypere G, Joen TSG (2005) Impact of sex reassignment surgery on lower urinary tract function. Eur Urol 47: 398-402.

51. Hage JJ, Bouman FG, Bloem JJ (1993) Construction of the fixed part of the neourethra in female-to-male transsexuals: Experience in 53 patients. Plast Reconstr Surg 91: 904-910.

52. Bouman FG (1987) The first step in phalloplasty in female transsexuals. Plast Reconstr Surg 79: 662-664.

53. Kim SK, Lee KC, Kwon YS, Cha BH (2009) Phalloplasty using radial forearm osteocutaneous free flaps in female-to-male transsexuals. J Plast Reconstr Aesthete Surg JPRAS, 62: 309-317.

54. Tank ES, Demuth RJ, Rosenberg S (1982) Reconstruction following amputation of the penis in children. J Urol 128: 386-388.

55. Djordjevic ML, Bumbasirevic MZ, Vukovic PM, Sansalone S, Perovic SV (2006) Musculocutaneous latissimus dorsi free transfer flap for total phalloplasty in children. J Pediatr Urol 2: 333-339.

56. Cohen-Kettenis PT, van Goozen SH (1997) Sex reassignment of adolescent transsexuals: A follow-up study. J Am Acad Child Adolesc Psychiatry 36: 263-271.

57. Deogracias JJ, Johnson LL, Meyer-Bahlburg HF, Kessler SJ, Schober JM (2007) The gender identity/gender dysphoria questionnaire for adolescents and adults. J Sex Res 44: 370-379.

58. Khouri RK, Young VL, Casoli VM (1998) Long-term results of total penile reconstruction with a prefabricated lateral arm free flap. J Urol 160: 383-388.

59. Yoo JJ, Park HJ, Lee I, Atala A (1999) Autologous engineered cartilage rods for penile reconstruction. J Urol 162: 1119-1121.

60. Nolazco G, Kovanecz I, Vernet D, Gelfand RA, Tsao J, etal (2008) Effect of muscle-derived stem cells on the restoration of corpora cavernosa smooth muscle and erectile function in the aged rat. BJU Int 101: 1156-1164.

61. Tuffaha SH, Sacks JM, Shores JT, Brandacher G, Lee WP (2014) Using the dorsal, cavernosal, and external pudendal arteries for penile transplantation: Technical considerations and perfusion territories. Plast Reconstr Surg 134: 111-119.

62. Hu W, Lu J, Zhang L, Wu W, Nie H, et al (2006) A preliminary report of penile transplantation. Eur Urol 50: 851-853.

63. Koga H, Yamataka A, Wang K, Kato Y, Lane GJ, et al (2003) Experimental allogenic penile transplantation. J Pediatr Surg 38: 1802-1805.

64. Zhang LC, Zhao YB, Hu WL (2010) Ethical issues in penile transplantation. Asian J Androl 12: 795-800.