

Free Tissue Transfer Penile Reconstruction

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Abstract

Phalloplasty can be a challenging plastic surgery procedure associated with complications and unsatisfactory results. Phalloplasty has become an important procedure in the setting of trauma, partial or complete excision of the penis, and gender affirmation. Advances in microsurgery has expanded penile reconstruction through free tissue transfer techniques which include the radial forearm free flap, fibular osteocutaneous flap, anterolateral thigh flap, latissimus dorsi flap, scapular flap, and abdominal flaps. Each procedure has advantages and disadvantages; most of the procedures achieve adequate cosmetic results with high patient satisfaction. Most of the surgical complications are related to the reconstruction of the urethra or creating rigidity for intercourse. The main goals of reconstruction are to create a cosmetically appealing phallus with satisfactory sexual function.

Keywords

- ▶ penile reconstruction
- ▶ phalloplasty
- ▶ free tissue transfer

Phalloplasty is a challenging plastic surgery procedure particularly when outcomes can be highly variable and unsatisfactory results can have a significant psychosocial impact on the patient. The inability to micturate or to engage in intimate acts can be associated with serious psychosocial sequelae. Phalloplasty has become an important procedure in the setting of penile agenesis (▶**Fig. 1**), trauma, partial or complete excision of the penis (i.e., oncologic), and gender affirmation. Due to need for tissue bulk, free tissue and pedicled flaps are often needed for phalloplasty when primary repair is not feasible with extensive tissue loss or in cases of gender affirmation surgery where there is minimal tissue to work with.¹ Despite advances in microsurgical techniques and robotic technology, penile reconstruction remains complex. No consensus on ideal reconstructive approach or even standardized outcomes is reported, and complications can be both commonplace and serious.²

Anatomy

The complex anatomy of the penis that lends it to receive sensory and motor input, as well as its unique erectile tissue makes it particularly difficult to reconstruct. The arrangement of the penile anatomy is a cylinder with the corpora cavernosa adjacent to each other, while the corpora spongiosum located inferiorly, all capable of erectile function. The urethra lies within the spongiosum. Inside each cavernosa lies a deep cavernosal artery that subsequently branch into helicine arteries. The layers of the penis from the skin inward include a superficial Dartos' fascia. This encases Buck's fascia which covers the corpora structures described previously.

Understanding the penile neurovasculature is essential to properly reconstruct the erectile properties. The internal pudendal artery branches off of the internal iliac artery and becomes the common penile artery. This then branches to supply the corpora through two cavernosal arteries, a



Fig. 1 Preoperative appearance of a 17-year-old boy with penile agenesis.

bulbourethral artery and a dorsal artery. Venous outflow from the penis occurs through emissary veins within the tunica albuginea. The penis receives sensory and somatic motor innervation from the pudendal nerve, while the erectile tissue is supplied by the cavernous nerves.¹

History of Reconstruction

There are several goals for an ideal reconstruction to accomplish. Gilbert et al suggested that the ideal phallic reconstruction should cover all five of the following criteria: a microsurgical procedure that takes place in one stage and is reproducible; construction of a neourethra that facilitates voiding while the patient is standing; a phallus with erogenous and tactile sensibility; sufficient bulk to permit prosthetic stiffener placement to make sexual intercourse possible; and an aesthetic result the patient finds satisfactory.³

Prior to the use of free tissue transfer, reconstruction relied on pedicle flaps. The first reported attempt for total penile reconstruction was performed in 1936 by Bogoraz using a bipedicle abdominal flap and rib cartilage following traumatic amputation.¹ Gillies and Harrison in 1948 introduced the first sexual reassignment surgery, creating the “tube within a tube” design, constructing a neourethra. Following this, there have been multiple procedures that have attempted penile replacement. These include multiple pedicle flaps, prostheses added to the pedicle flaps, tube-within-a-tube-design microvascular free flaps, and recently, penile transplantation. The complications of these procedures remain relatively high with most of the complications related to reconstruction of the urethra. Despite this, patient’s satisfaction remains high.² While standing to void is a very high priority for female-to-male transsexual patients, the highest priority for patients with congenital penile absence is the ability to achieve rigidity sufficient for sexual intercourse.⁴

Microvascular Free Tissue Transfer

Advances in microsurgery have expanded penile reconstruction through free tissue transfer techniques which include

the radial forearm free flap (RFFF), fibular osteocutaneous flap, anterolateral thigh (ALT) flap, latissimus dorsi (LTD) flap, scapular flap, and abdominal flaps.^{1,5–39} The deltoid flap was successfully used in the past, but it creates a wider and shorter than normal neophallus, making it difficult to accommodate a prosthesis for intercourse.⁴⁰

Preoperative Evaluation

Prior to reconstructive surgery, all patients should be evaluated by mental health colleagues to better understand the patient’s goals and expectations. Additionally, perioperative involvement of an endocrinologist with expertise in such disorders is essential in cases of gender reassignment. A thorough history and physical examination are performed, focusing on sensation of the genital area, the ability to obtain an orgasm, management of urinary system (spontaneous voiding vs. intermittent catheterization), presence or absence of a scrotum, and potential donor-site evaluations. Factors such as skin integrity, vascular health, pigmentation match, and hair growth should all be considered. It is also important to review all other comorbidities including diabetes, smoking history, urinary tract infection, and hygiene. The goals of neophallic construction are reviewed with the patient including creating an aesthetically pleasing phallus, sufficient rigidity for intercourse, sensations sufficient for orgasm, the ability to convey urine or sperm, and minimizing morbidity. This preoperative evaluation information is the opinion of the senior author (B.K.).

Radial Forearm Free Flap

The RFFF is the most commonly used flap and arguably the “workhorse” for phalloplasty. Reported outcomes of the RFFF account for more than 75% of all cases in the literature. Usually, this technique is performed in one to three stages.¹ Typically, to allow for adequate healing time between surgeries, each stage is performed 3 months apart over a period of at least 1 year.⁴¹ The first stage involves harvest and inset of the flap. The flap is harvested from the nondominant arm with both the cephalic and basilic veins, as well as the radial artery. The flap is then divided after being harvested, with a portion being used to form a narrow, skin tube to function as a neourethra. A 16-French Foley catheter is used to stent the neourethra. An anastomosis is performed between the neourethra and the native urethra that is lengthened from the perineum through the addition of labia minora tissue. Buccal mucosa can be harvested if repair or lengthening is needed. The clitoris can be maintained at the base of the phallus for stimulation when phalloplasty is performed for gender reassignment surgery. The second stage usually consists of creating the neoglans. A glansplasty can be performed using a Norfolk technique to roll a strip of skin circumferentially and split-thickness skin grafting to fill the defect. Tattooing of the glans can be performed for cosmesis. The final stage is insertion of a prosthesis for stiffening, which normally is performed 1 year after to allow for sensory nerve recovery. The decision for this third step depends on patient preference and outcomes vary greatly.¹

Potential complications of the RFFF include complete flap loss (1.5%), partial flap loss and/or distal necrosis (7.4%), urethral fistula formation (29.6%), urethral strictures (8.2%), incomplete skin graft take requiring regrafting (2.7%), and decreased strength and/or sensation (2.6%).¹ The main drawback of the RFFF is the donor-site morbidity, which can include neuroma, cellulitis, nerve compression/compartment syndrome, decreased grip and pinch strength, cold intolerance, decreased wrist range of motion, paresthesias, and radius bone fracture. Other less common complications include acute thrombosis, pulmonary embolism, wound hematoma, contracture, meatal stenosis, poor wound healing, lymphedema, groin cellulitis and abscess, recurrent tumor, hydronephrosis, penile fracture, poor sexual performance, and psychiatric sequela (mental illness and suicide).^{1,5-10,17,41} Inserting a penile prosthesis in a phalloplasty is associated with several complications including infection (11.9%), erosion (8.1%), and mechanical failure (22.2%). The overall revision rate can be up to 41% after 4 years.⁴²

The reported outcomes with the RFFF are generally favorable despite not satisfying all of Gilbert's criteria.¹ In one study, 87% of patients reported sensation, 97% were satisfied with cosmesis, and 99% had the ability to urinate while standing.¹² The success of the RFFF is very reliant on flaps that are innervated. One study by Ma et al showed that innervated flaps had sensation in 75% and were able to achieve orgasm in 80%, while noninnervated flaps showed only 18 and 50%, respectively. Overall, between 75 and 100% of patients reported being able to void while standing. Erogenous and tactile sensibility was deemed sufficient in 51 to 100% of patients. In almost all studies, satisfaction with cosmesis was a commonly reported outcome.⁹ There remains challenges at interpreting these results, however, given the lack of standardized objective outcome measures to assess satisfaction. After implanting an inflatable penile prosthesis, up to 60% of patients have a normally functioning erectile device, which can be used in sexual intercourse.⁴²

Fibular Osteocutaneous Flap

An alternative reconstructive option for phalloplasty is the fibular osteocutaneous flap.¹⁹⁻²⁴ While the sensational advantages of the RFFF cannot be disputed, the bony component of the fibula flap adds durable rigidity for sexual intercourse that can eliminate the need for a prosthesis.^{1,19} Typically, this flap has three stages: harvest (→ Fig. 2) and prelamination of the neourethra with split-thickness skin graft for 6 months before flap inset; inset of the free sensate osteocutaneous fibular flap (→ Fig. 3); and urethral anastomosis. Complications from five studies in 135 fibula osteocutaneous flaps include complete flap loss (1.5%), partial flap loss/distal necrosis (11.9%), urethral fistula (9.6%), and urethral stricture (17%). Donor-site complications are not well reported in the literature.¹ Other complications included poor wound healing, infection, inflammation of the neoscrotum, neourethra stenosis, and prosthesis failure.¹⁹⁻²³ One study by Schaff and Papadopoulos comparing the fibula flap to the RFFF found that patients who underwent the fibular flap



Fig. 2 Intraoperative design of an osteocutaneous fibula free flap.



Fig. 3 Appearance after inset and microvascular anastomosis of fibula free flap.

interestingly experienced better sexual intercourse but had worse sensation. All patients reported the ability to void while standing, as well as satisfactory sexual intercourse, with minimal donor-site morbidity.²⁰ Overall, the results of the fibular osteocutaneous flap are functionally and cosmetically favorable (→ Fig. 4).

Anterolateral Thigh Flap

The ALT flap is yet another alternative for phalloplasty because it is safe, sensate, and hairless, with a long pedicle and adequate volume of soft tissue for manipulation.²⁵⁻³¹ Felici and Felici first used the ALT free flap in phalloplasty; however, the advantages of the pedicled version has become apparent in recent years.³⁰ The pedicled ALT flap minimizes donor-site morbidity and need for microsurgery, which are characteristic drawbacks of both the radial forearm and fibular flaps.¹ The minimal donor-site morbidity is a particular advantage and important to the female-to-male transgender patients as the forearm scar can be considered a visible stigma that is difficult to camouflage or hide under clothes during the temperate months depending on geographic location.^{30,31} The first step of the procedure involves raising the flap, which is supplied by a descending branch of the lateral circumflex femoral artery, and innervated by branches of the femoral cutaneous nerves. The flap is then



Fig. 4 Postoperative appearance after 40 months.

tunneled beneath the rectus femoris and sartorius to the pubic region as an island flap. The neophallus is formed using a tube-within-a-tube design. Finally, the procedure concludes with neurotomy and urethral anastomosis.¹ One disadvantage of this flap is the anatomic variability of perforator vessels; however, other studies have shown that the anatomy is quite consistent.³⁰

In one systematic review, the reported complications included partial flap loss (12.5%), urethral fistula (37.5%), and urethral stricture (12.5%). No patients experienced complete flap loss. Other complications include ischemic changes with vascular congestion, meatal stenosis, wound dehiscence, and cellulitis. Outcomes of the ALT flap are generally good, with 100% of patients reporting sensation of at least the proximal half of the neophallus. Most studies have also reported results fulfilling the majority of Gilbert's criteria.^{25–28,30} Several studies have reported that the ALT flap offers better color matching and is less prone to atrophy than the RFFF.^{25–27} The pedicled ALT flap also has the advantage of being a single-stage phalloplasty compared with many other free flap options. Present studies are limited by a small sample size, a problem intrinsic to the rarity of the need for the reconstructive procedure, and lack standardization of a set of objective outcome measures.¹

Latissimus Dorsi Flap

The LTD free flap is another option for phalloplasty.^{1,32–35} The LTD flap allows for a favorable aesthetic donor site while

providing enough tissue for reconstruction and prosthetic placement for successful intercourse. The flap is elevated in a plane between the latissimus and serratus anterior muscles. The blood supply is the thoracodorsal artery and innervation is by the thoracodorsal nerve. Additional flap bulk can be achieved by adjusting the muscular cuff around the vascular pedicle on ligation. The flap skin is shaped into a tube to create the neophallus as previous techniques have demonstrated. Finally, the muscular portion of the flap can be connected to the rectus abdominis fascial sheath at the base of the neophallus. Complications of the LTD flap include hematoma formation (11.5%), vascular thrombosis (3.3%), partial flap loss/distal necrosis (1.6%), urethral fistula (3.3%), and skin graft loss (1.6%). There are no reported instances of complete flap loss or urethral stricture. This flap also permits voiding with standing and meets aesthetic patient expectations. An inherent disadvantage to this flap may be the patient positioning required for flap harvest. In addition, the LTD flap allows for a “paradox erection,” where flexion of the calf and adduction of the thigh causes shortening and widening of the neophallus given a portion of free muscle transfer, allowing voluntary motor function, a unique result of this flap not described previously.^{1,35}

Scapular Free Flap

Another option for phalloplasty with minimal donor-site morbidity is the scapular free flap. First, the circumflex scapular artery is identified. The flap must be properly planned out prior to execution and requires conceptualization of three key subunits: a medial portion intended for urethral reconstruction, a lateral portion utilized for shaft reconstruction, and a central de-epithelialized strip. A key difference in this technique is the use of a malleable penile prosthesis is inserted immediately before flap anastomosis on initial stage rather than in later stages as previously described. Few studies have looked at the outcomes and unfortunately no standard or validated outcome measures were used. Complications of the scapular flap include complete flap loss (2.9%) and urethral fistula (8.6%). No partial flap loss/distal necrosis or urethra strictures have been reported.^{1,36,37} Overall, patients reported satisfactory cosmesis and ability to void while standing. In one series, 67% of patients were satisfied with their sexual performance.³⁷

Conclusion

Phalloplasty can be a very complicated and complex surgical reconstruction. Multiple procedures exist that all have their advantages and disadvantages. The most extensively reported free tissue transfer remains the RFFF. Lack of objective and validated outcome measures are the primary hurdles for meaningful outcome studies and make interpretation of retrospective studies difficult. Most of the procedures achieve adequate cosmetic results with high patient satisfaction.² Most of the surgical complications are related to the reconstruction of the urethra or creating rigidity for intercourse. The main goals of reconstruction are to create a cosmetically appealing phallus with satisfactory sexual function.

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Conflict of Interest

None declared.

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