

Penile Reconstruction

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Abstract

A wide variety of surgical options exist for penile reconstruction. The key to success, however, is not only in choosing the most functional operation, but also focusing on both the physiological and psychological management of the patient. In this article, we review reconstructive modalities for various partial and total penile defects, as well as the buried penis. Our description of recent scientific advances and the emphasis on a holistic approach to patient care, may promise new options in penile reconstruction and help both patients and physicians achieve the best end result.

Introduction

Penile reconstruction serves as a solution for a complex patient population, but not without a series of issues. The loss of the penis negatively affects many domains of one's personal life including their interpersonal relationships, self-confidence and psychological well-being. As a result, management consists of not only surgical reconstruction but also psychological rehabilitation. Doctors must educate their patients on surgical options, reasonable expectations and possible complications as well as psychological difficulties patients often face.

The goal of penile reconstruction is to either create or restore both a functional and aesthetic phallus. This includes not only the ability to void while standing, from the tip of the phallus, but also to achieve sexual function, with a sensate penis of sufficient bulk to allow for penetration. Generally, the extent of the defect dictates the means of reconstruction we chose for our patients. A surgical defect may range from one involving a single tissue or structure (i.e. skin or urethra,) to a total penectomy defect, requiring microsurgical reconstruction. The buried penis presents another interesting problem that demands a somewhat different surgical approach and procedure.

Additionally, the appearance of the reconstructed phallus is equally important and should resemble a normal penis in all aspects from glans to shaft. Still, some procedures require even more complex procedures such as immediate scrotal reconstruction and testicular prosthesis placement. In this article, we aim to present the various penile defects that physicians may encounter and hope to help guide both the physician and patient into choosing the surgical modality best suited for their individual case.

Patient Evaluation

The patients presenting for penile reconstruction are often very complex, requiring both physical and emotional support. Of note, many transsexual candidates and/or victims of acute or unexpected penile trauma should explore non-surgical treatment options to treat their sexual dysfunction as a first-line therapy. Hence, a thorough psychiatric history and evaluation is essential as many of these patients suffer from depression and suicidal ideation. That being said, this should not exclude them from surgical reconstruction since the deformity is often the source of the psychological distress. The physician's primary approach should be to resolve psychological problem before surgical treatment and to work collaboratively with a psychiatrist throughout treatment.

The patient's sexual history should be evaluated and reviewed to

determine such issues as premonitory length of the penile shaft and whether the patient is currently able to achieve orgasm. The means by which the patient voids is also critical, as the presence of a perineal urethrostomy will have bearing on the surgical plan. Furthermore, the patient's tactile and protective sensation in the region of the penile remnant should be assessed, and whether nerves such as the pudendal, ilioinguinal or genitofemoral nerves are intact. In total penile reconstruction, these nerves may be reapproximated to the neophallus to achieve protective and erogenous sensation. As many of these intimate questions are essential to the success of surgical reconstruction, a trusting relationship must be cultivated between the physician and patient. This will also help ensure realistic patient expectations, which are imperative to postoperative success.

Another important issue to most patients is the length of the penis and sensation. We found the average penile length to be around 6 inches [1,2]. Additionally, we advise our patients that even if the operations are successful and the reconstructed penis functions properly, the patients are not likely to have the same sensation as they did previously. Of importance if microsurgical reconstruction is to be performed, it is vital to ensure that the patient stops smoking at least 4 weeks before surgery and also abstains after surgery. Discussing these issues with the patient in advance will help prevent unrealistic expectations and encourage their cooperation pre- and post-operatively. The diagnosis and treatment of penile trauma is still evolving and the long-term sequels of these injuries may best be treated by urologists and plastic surgery experts in urogenital reconstruction [3].

Partial Penile Defects

If there is partial preservation of the penile shaft, measures to augment penile length may be sufficient to achieve a functional phallus [4,5]. These measures include severing the suspensory ligament or with V-Y plasty of the lower abdominal skin. An illusion of increased

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penile length is perceived as a result of penile descent and increased convexity of the penile base. This reconstructive option is suitable for defects with a remnant penile length of 2-3 cm and a patient maintains the ability to urinate in a standing position. In older patients with multiple comorbidities, penile augmentation with dermal fat grafts or hyaluronic acid may be an adequate option in lieu of complex free flap surgery. Complications may include "scrotalization" where the penis becomes covered by unsightly scrotal corrugated skin rather than by natural smooth skin, hypertrophic scarring and a low hanging penis [6]. Three-dimensional digital models, animations, and simulations have been used in the plastic surgical field for surgical education and training and patient education. In penile lengthening surgery, proper patient selection and well-designed surgical interventions are necessary. Three-dimensional digital models and animations of penile lengthening surgery may serve as resources for patient education to facilitate patient selection and resident education outside the operating room and help reduce the complications [7].

Isolated skin loss may result from penile trauma, burns or excisional debridement of hidradenitis suppurativa. In these cases, split thickness skin grafting allows good reliable coverage. Increased use of vacuum assisted closure (VAC) dressing (Kinetics Concepts Incorporated, San Antonio, TX) in these difficult areas has resulted in increased skin graft take and improved results. In cases not amenable to immediate split-thickness skin grafting, Integra (Integra Life Sciences Corp, Plainsboro, N.J.), a dermal substitute comprised of bovine collagen, results in a newly vascularized bed and may allow for skin grafting after removal of its overlying silicone sheeting 3 weeks post-application (Figure 1). Scrotal skin flaps based on the anterior and posterior scrotal arteries may also be used in cases of skin deficiency [8], and are also used in reconstruction of partial penectomy defects [9]. Dr. Sinha employed a split-skin graft for the glans and full-thickness graft for the shaft to achieve a more natural cosmetic appearance [10].

In rare cases, such as Sickle Cell Disease, a patient may present with isolated erectile dysfunction not amenable to reconstruction with prostheses. A prefabricated cadaveric bone flap based on the descending branch of the lateral circumflex femoral artery has been used as a pedicled flap and implanted within the corpora cavernosa to restore sexual function [11]. For some special cases, simultaneous penile prosthesis implantation and corporal reconstruction of severely scarred corpora yield satisfactory results [12].

Urethral Reconstruction

Urethral defects requiring reconstruction by the plastic surgeon are rare. However, in cases of carcinoma of the anterior urethra or penile shaft, partial penectomy or total penectomy with a perineal urethrostomy may occur. These patients are often not good surgical candidates for reconstruction due to age and comorbidities. In patients with advanced bladder cancer requiring cystectomy with total urethrectomy, urethral reconstruction is not required, as urinary diversion will be performed through the medium of an ileal conduit.

Reconstructive techniques are based on the approaches needed to treat urethral strictures. The penile urethra may be exposed through an inverted T-shaped incision on the ventral surface of the penis, or a circumferential incision about 0.5 cm below the glans. The bulbar urethra is best approached through a midline line perineal incision, which provides good access to the posterior urethra. Urinary diversion through a urethral or suprapubic catheter is key to success of reconstructive procedures. This catheter concurrently stents the reconstruction to prevent strictures. Typically, after 10 to 14 days, a cystourethrogram

is performed to verify that absence of urinary extravasation. In cases of significant extravasation, the cystourethrogram is repeated after 1 week and urinary diversion maintained.

In small defects less than 2 to 3 cm, urethral ends may be mobilized from the corpora cavernosa and spatulated [13]. A primary interrupted anastomosis is then performed. If a tension-free anastomosis cannot be achieved, anastomosis of the dorsal or ventral strip with augmentation onlay of the opposing side may be performed. A buccal mucosal patch or skin flap may be also be used as an onlay to fill the defect [14,15]. If a free graft is used, care must be taken to ensure the graft lies against a well vascularized bed. The location of the buccal mucosa graft on ventral, dorsal or lateral aspects of the bulbar urethra has been shown to result in similar success rates [16]. In cases of a circumferential urethral defect, a pedicled skin flap based on the prepuce, penile shaft or scrotum may be used for reconstruction [17-20]. Some doctors complete urethral reconstruction using a superficial circumflex iliac artery, a prefabricated pedicled grackles flap, a novel fasciocutaneous flap and so on. Of course, different materials and type have some special advantage [19-21].

Reconstruction of Total Penile Defects

Total penile defects requiring reconstruction may result from a variety of mechanisms ranging from trauma to malignancy. Penile amputation has been reported from causes ranging from domestic violence to bizarre cases such as strangulation by a metallic nut [22] or self-amputation due to schizophrenia [23]. When the penis is intact and amputated sharply, microsurgical replantation results in the best outcome. More often, recruitment of adjacent or distant tissue is required to effect a functional and aesthetic reconstruction.

While pedicled flaps such as groin [24] or abdominal skin flaps, rectus abdominis and gracilis have been used historically and recently for penile reconstruction, these lead to suboptimal results with poor aesthetic and functional outcomes. Hence, microsurgical free flap reconstruction has become the method of choice for penile reconstruction. The ideal flap should be one that is sensate and hairless, with sufficient tissue to allow tubularization, as well as with a long pedicle. The radial forearm flap fulfills these requirements, and is by far the most commonly used free flap for penile reconstruction.

Radial forearm flap

Chang and Hwang first described the radial forearm flap in 1984 for total penile reconstruction [25] and has been found to be superior to all other techniques [26,27]. The radial forearm flap has the advantage



Figure 1: A) 64-year-old, otherwise healthy, male presented with an ulcerated lesion on his glans penis. Pathology consistent squamous cell carcinoma *in situ*. B) Following partial glansectomy and reconstructive with bovine collagen. The foley catheter was removed after one week. C) Three weeks after the first procedure, the patient underwent removal of the Integra silicone layer and replacement with a non-meshed partial thickness skin graft. Patient is shown at 6 months postoperative.

of providing thin supple tissue as well as a long pedicle that is easily exposed and dissected. It allows the best recovery of sensation among various flaps used for penile reconstruction. The location of the donor site away from the groin also allows a two-team approach.

A preoperative Allen test is essential to ensure that vascularity of the hand will not be compromised with harvest of the radial forearm flap. In a typical surgical scenario, two surgical teams operate simultaneously. The urologist performs the resection and also prepares the urethral stump. At the same time, the plastic surgeon raises the flap on the non-dominant forearm. Prelamination of the neourethra may be performed prior to the definitive surgery, most often with a split-thickness skin graft over a stent [28]. Alternatively, if prelamination is not performed and the procedure is performed in a single stage, the ulnar skin can be used to create a “tube-within-a-tube” phallus [27,29].

To restore tactile and erogenous sensation, the medial and lateral antebraclial nerves are identified and preserved. These are anastomosed to the ilioinguinal nerve for protective sensation and dorsal penile or dorsal clitoral nerve for erogenous sensation. By nature of the vessels available in the region of the penis, microsurgical reconstruction is most often performed with anastomoses to the femoral artery and great saphenous vein or inferior epigastric vessels. A case is illustrated in figure 2.

If bone from the radius is harvested to provide extra rigidity of the neophallus, prophylactic plating may be used to decrease the incidence of subsequent radius fractures [30]. Otherwise, penile and testicular implants are placed after 12 months to allow sexual intercourse, following return of protective sensation to the penile tip. The forearm donor site is covered with split-thickness skin grafts or full thickness skin grafts from the groin. Post-operative urinary diversion is essential to protect the urethral anastomosis. Tattooing of the glans can be performed 2 to 3 months latter to improve the aesthetic result.

The incidence of urinary complications such as urethrocutaneous fistula or urinary stricture following penile reconstruction is significant, with a rate of around 41% reported in two studies [27,31]. The majority of fistulas can be treated conservatively, while most strictures can be treated with dilation. Interestingly, the radial forearm flap has also been described for penile reconstruction using non-microsurgical technique [32]. In this technique, an osteocutaneous radial forearm flap is elevated as a reverse-flow island flap and transferred to the recipient site as a distant flap while maintaining its vascular connection with the forearm. The pedicle is then divided and the reconstruction completed 2 to 3 weeks later. The authors, however, have no experience with this form of reconstruction. In a word, the radial artery-based forearm free flap technique is excellent for total phallic construction, providing excellent cosmetic and functional results [33].

Free fibular flap

Sadove et al. described the free sensate osteocutaneous fibular flap in 1992 for total phallic reconstruction [34]. The advantages of the flap are its intrinsic rigidity, concealed donor site and long vascular pedicle. The increased bone stock available obviates the requirement for a penile implant for intercourse. However, disadvantages include decreased sensibility, increased urethral complications and permanently erect penis that may cause distress and social embarrassment. Despite decreased sensibility with the fibular flap, better sexual intercourse has been reported by patients compared to those reconstructed with the radial forearm flap [35]. As a result, this flap is preferred by some for penile reconstruction, particularly in patients who refuse the radial forearm donor site.

Anterolateral thigh flap

The pedicled anterolateral thigh (ALT) has experienced increasing popularity in recent years for total phallic reconstruction [36-38]. Unlike previously used pedicled flaps, the ALT flap provides a superior aesthetic outcome and also allows restoration of sensation through coaptation of the lateral femoral cutaneous nerve to the pudendal or dorsal penile/clitoral nerves. A major advantage over the radial forearm flap is the concealed donor site. An erectile prosthesis can also easily be implanted. Other authors have described using the ALT as a free flap for phalloplasty [39].

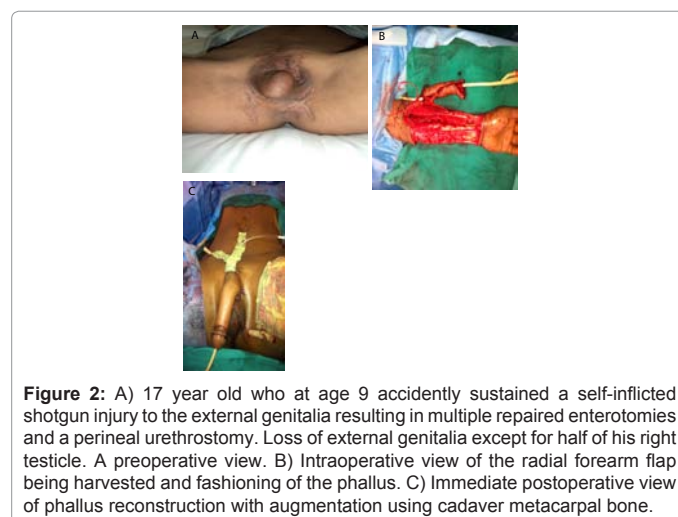
Other reconstructive options

In efforts to improve the donor site scar, the thoracodorsal artery perforator flap has been used for phallic reconstruction [40]. The concealed donor site and large reservoir of tissue are obvious advantages of this technique. A pedicled suprapubic abdominal wall flap has also been described in a series of 85 transsexual patients for phalloplasty [41]. While the technique resulted in a good cosmetic result with the ability to achieve sexual intercourse with the aid of a penile implant, a major limitation was the high rate (75%) of urinary complications. Finally, penile transplantation has been described in an isolated case report [42]. While the recipient could urinate standing 10 days after surgery, the transplanted penis was cut off at day 14 due to psychological issues.

Management of the Buried Penis

The “buried” penis [43] is an unusual condition that results in significant psychological and physical symptoms, and is associated with morbid obesity and diabetes mellitus in adults. Some described surgical techniques consisted of a minimal incision and simple fixation of the penile shaft skin and superficial fascia to the prepubic deep fascia, without degloving the penile skin [44]. This has been defined as a penile shaft buried below the surface of the prepubic skin and also to a partial or totally obstructed penis caused by obesity or radical circumcision [45]. Increase in suprapubic fat results a moist environment around the penis, which may result in chronic infection, skin breakdown and subsequent scar contracture. This results in a penis, which is not obvious on immediate inspection. Other causes may include penoscrotal elephantiasis or chronic genital lymphedema.

Pestana et al. [43] described a treatment algorithm which may



be used in adults with buried penis. Release of scar contracture and removal of adjacent excess abdominal tissue through suction lipectomy, panniculectomy, or both allows exposure of the penis. Tacking sutures from subdermal tissue at the pubis to rectus fascia or pubic periosteum prevent retraction of the penis into the pubis or scrotum and maintain elevation of the suprapubic region [46]. Finally, reconstruction of the skin defect is achieved through local tissue rearrangement or skin grafts (split or full thickness). This is illustrated in figure 3 below.

Recent Developments

Since the use of current penile reconstructive techniques is limited by issues of tissue compatibility and availability, physicians have begun to explore tissue bioengineering for penile reconstruction in order to reduce or eliminate complications. Tissue bioengineering allows the development of biological substitutes, which could potentially restore normal function. This bioengineering method involves the use of synthetic or natural matrices labeled scaffolds. When used alone, some scaffolds can facilitate the body's natural ability to regenerate by directing new tissue growth [47]. This scaffold can also be seeded with cells and the resulting construct can be implanted into the patient in order to restore the structure and function of damaged tissues and organs.

So far, there are several methods used to culture cells, these methods allow 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 may be able to generate large amounts of tissue required for penile reconstruction without the donor site morbidity associated with grafting procedures mentioned above. In addition, the bioengineered tissue would be biocompatible and the risk of rejection would be eliminated [47].

Recent advances in tissue engineering promise new options for penile reconstruction. While research has not been translated beyond animal studies, remarkable progress has been made in recent years. Bioengineered penile prosthesis and specific penile structures such as urethral repair prosthesis, coporal bodies and tunica albuginea are also in progress [48]. Briefly, the penis is composed of corpora cavernosa and is involved in erectile function. Extensive reconstructive procedures involving coporal bodies may be needed in patients with trauma to the penis, malignancy, etc. Due to the shortage of autologous tissues, these surgical procedures are typically staged and often utilize

non-genital tissue as a grafting source. These procedures have a high risk of complication due to infection, donor site morbidity and graft failure [48]. The creation alternative materials are a major challenge for phallic reconstruction due to the unique anatomical architecture of the corporal bodies.

Acellular corporal collagen matrices seeded with autologous cells have been used to replace entire pendular penile corporal bodies in a rabbit model [49]. Remarkably, the engineered tissue was similar structurally and functionally to native tissue, and male rabbits were able to successfully impregnate females. Tissue engineered cartilage rods have also been used as a substitute for synthetic penile implants. Autologous chondrocytes seeded on a polymer lattice rod were implanted into corporal spaces of the same rabbits, and explantation after 2 months showed well-formed cartilage structures, with animals able to copulate and impregnate female partners. An additional study utilizing human chondrocytes were implanted into subcutaneous spaces of rats for duration of 2 months to produce cartilaginous rods of comparable size and mechanical properties to silicone prostheses [50]. Stem cells may also be a novel treatment option. One study has reported differentiating rat muscle-derived stem cells into corporal smooth muscle cells to replace these *in situ* [51]. Another study by Song et al. [52] observed the differentiation of human mesenchymal stem cells into smooth muscle cells or endothelial cells upon transplantation into rat corpus cavernosum [52]. Vascular endothelial growth factor (VEGF) is expressed in pedicle penile skin flaps (PPSFs), used for urethral reconstruction in rabbits. Flap angiogenesis is much higher than angiogenesis in simple wound closure. VEGF injection on postoperative day 3 seems to enhance angiogenesis in flaps [53]. Current research demonstrated that neocorpora could be engineered for total pendular penile corporal body replacement. The technology has considerable potential for patients requiring penile reconstruction [54].

Conclusion

Penile reconstruction is a complex endeavor that requires close cooperation between the plastic surgeon and urologist. Often, not only the surgical, but also psychological aspects of treatment will determine success or failure of therapy. Regardless of the method of reconstruction, the goals of surgery remain the same. These include creating a functional and aesthetic phallus with the ability to void standing and to achieve sexual function. In the future, tissue engineering and stem cell technology may have an important place in the treatment of these patients who will receive penile reconstruction [55].

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Figure 3: A) 58 year old gentleman presented with complaints of "not being able to see his penis". A buried penis diagnosis was given and gynecomastia lipectomy performed. Early postoperative view at 6 weeks.
A. Preoperative view shown.
B. Design of planned skin and subcutaneous resection.
C. Intraoperative specimen of gynecomastia.
D. Early postoperative view at 6 weeks.

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