

Review

Genital flaps for anterior urethral reconstruction

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Abstract

Genital flaps can provide versatile options for complex penile, genital, and urethral reconstruction. Pedicled muscle flaps can be used in combination with grafting for urethral reconstruction and genital skin flaps can also be utilized as urethral augmentation or replacement. Penile skin flaps, in particular, offer versatile options for management of anterior urethral stricture disease. The choice of urethral reconstruction depends on surgeon expertise and patient disease. Flap reconstruction, given its surgical complexity is equally dependent on appropriate understanding of patient disease and surgeon experience. It is crucial to understand the patients' comorbid diseases (e.g., smoking status or lichen sclerosis), potential flap tissue quality (i.e., penile/preputial skin quality), and stricture anatomy (length, caliber, location). Of particular importance is any prior intervention that may alter the normal vascular supply to the proposed

flap. The ideal skin flap will be (1) hairless; (2) accustomed to the aqueous environment; (3) adaptable; (4) cosmetic. This review will cover the operative approaches and peri-operative outcomes of genital flaps for management of urethral reconstruction. Particular attention will be paid to penile skin flap urethroplasty.

Keywords: Urethral stricture, genital flap, penile flap, reconstructive urology

INTRODUCTION

Urethroplasty is the gold standard for treatment of urethral stricture disease. While urethroplasty techniques can be technically demanding and can have significant associated learning curve, the success rates are excellent and significantly better than endoscopic alternatives^[1]. Urethral grafting, genital skin flaps, and combined tissue transfer provide durable options for single or two-stage repairs. There is no consensus on a single best reconstructive technique as the efficacy of each technique in restoring urethral patency varies with both patient disease and surgeon expertise^[2,3].

Anterior and posterior urethral strictures are considered separate disease processes and flaps do not currently play a role in posterior urethral reconstruction. This review will focus, therefore, on the use of genital skin flaps, particularly those derived from penile skin, in anterior urethral reconstruction. Special consideration should be taken for cases of urethral reconstruction in patients with a neophallus. Urethral reconstruction in these patients is inherently complicated as vascular supply of the neophallus is derived from a non-anatomic pedicled flap. The description of penile skin flaps is therefore not applicable in reconstruction of the urethra in neophallus as penile skin flaps depend on native penile vasculature. For the purposes of this review, the focus will be on male anterior urethral stricture disease with native penile tissue. Patient selection, flap characteristics, focused genital anatomy, and types of flaps will be discussed. Operative approaches and recommendations on the use of each flap will be provided in addition to an overview of published success rates

PATIENT SELECTION

Appropriate understanding of patient comorbid disease is essential in choice of urethral reconstruction. The approach to genital flaps in particular can be surgically challenging and appropriate patient selection is crucial. Patient comorbid disease, particularly conditions that can compromise blood flow are important to understand as they can affect both flap failure and wound healing. Patients with a history of smoking, peripheral vascular disease, or radiation are all at higher rate of flap failure^[4]. Physical examination to assess penile/genital skin integrity and concomitant wounds, fistulae, or abscesses is also important to select appropriate flap locations and counsel patients on post-operative expectations. Presence of lichen sclerosis (LS) bears particular mention. While there are reports of using flaps from uninvolved genital skin in patients with LS, the success rates are lower and often a two-stage approach has been preferred in this population^[5-7]. Skin involved with LS should not be used for urethral reconstruction.

Stricture location and length often indicate the surgical technique best suited for repair. Genital flaps with or without combined tissue transfer can play a role in bulbar urethroplasty, but in general anastomotic or buccal mucosal grafting (BMG) is preferred in the bulbar urethra. The tunneling of penile skin into the perineum adds additional technical challenges – which makes this technique less favorable given the durable success rates of BMG^[8-12]. In general, flaps have fallen out of favor as a mainstream reconstructive option in favor of BMG due to risk of flap loss, increased technical demands and patient satisfaction^[13,14]. In the appropriately selected patient, however, flaps still offer excellent success. Obliterative strictures can be particularly challenging to manage as these have insufficient dorsal urethral plate to perform onlay techniques. For short obliterative strictures (< 2cm), particularly in the bulbar urethra, anastomotic urethroplasty with excision of the obliterated urethra is preferred due to high published success rate. For longer obliterative strictures the dorsal urethral plate requires reconstruction. In these cases, combined tissue transfer with dorsal graft (e.g., BMG) and ventral skin flap can be used. Two-stage repair where the first stage reconstructs the dorsal plate can also be considered. Tubularized repairs are not preferred and should be avoided if possible.

Patient age and goals are also important for patient counseling and choosing the appropriate reconstructive technique. For older men with significant comorbidities, operations with less time in lithotomy position or highest single-stage success may be preferred to durability of repair.

Paramount to this discussion is an understanding of patients' sexual function. There is emerging evidence that non-transecting techniques may preserve sexual function and may be favored in patients of younger age^[15]. De novo persistent erectile dysfunction is rare following anterior urethroplasty (~1%)^[16].

Flap characteristics

There are 4 primary factors that characterize the ideal flap. Flaps should be 1) hairless 2) accustomed to the aqueous environment 3) adaptable 4) cosmetic^[17]. Each factor will be discussed briefly, with more depth provided in the discussion of individual flaps.

Hairless

Flaps should be derived from non-hair bearing skin. Hair in chronic contact with urine will lead to bacterial urethral colonization, stone formation, and inflammation. Accordingly, penile prepuce and distal penile shaft skin are preferred over proximal penile shaft and scrotal skin.

Aqueous environment

Choice of urethral augmentation should preferentially favor tissue that is accustomed to or adaptable to aqueous environment. Skin not accustomed to this environment will become inflamed and will be prone to squamous metaplasia. Chronic inflammation and metaplastic changes are concerning for both stricture recurrence and malignant transformation. This includes skin that is already diseased with active inflammatory processes (e.g., LS).

Adaptable

Ideal flaps should provide adequate urethral caliber in varying locations and be mobile enough to treat strictures in variable locations in the urethra. This includes skip lesion strictures. While non-hair bearing skin can be found elsewhere in the groin, non is as adaptable as penile skin.

Cosmesis

Creation of suture lines that approximate anatomic skin markings is an important consideration in choice of flap. Concomitant skin conditions such as vitiligo should also be considered for choice of flap location. Additionally, the possibility of debilitating another structure is another consideration for flaps, particular for use in tissue transfer.

SCROTAL AND GENITAL ROTATION FLAPS

Scrotal and various rotational flaps (e.g., anterior thigh) were popularized prior to the wide use of penile skin flaps and BMG. Now primarily of historic importance these flaps tend to fail to meet one or more of the four factors necessary for flap success. Scrotal flaps were at one point widely used, but the incorporation of hair-bearing skin into the urethra lead to unacceptable long-term outcomes with stones and infections^[18-24]. Other flaps including the incorporation of thigh skin which may not be hair bearing had comparatively short pedicles and were not appropriate in the reconstruction of the penile urethra. With rare exception these skin flaps have been abandoned for use as urethral replacement.

The use of non-skin pedicled rotational flaps (i.e., gracilis) as an interposition layer for fistula reconstruction and in combination with grafting continues to be actively used and investigated^[25]. For example, rotational gracilis flaps have been combined with BMG to manage complex bulbar strictures^[26]. Full discussion of these cases is outside the scope of this review.

Penile skin flaps

Penile skin flaps can provide single-stage reconstruction, even in long-segment anterior urethral stricture disease. Penile skin, particularly distal or preputial skin, in the appropriately selected patient will meet the four primary factors for an ideal flap. These flaps share a common blood supply from the external pudendal artery and involve isolation of a skin island that is mobilized for urethral reconstruction. Penile flaps are best characterized by the location/orientation of the harvested skin island, the pedicle origin, and the way in which the flap is incorporated into the urethra^[17]. Flap techniques have also acquired the eponym of the surgeon who first described that technique. Details and success rates of penile skin flaps are discussed below and are summarized in Table 1.

Penile anatomy

Appropriate utilization of penile skin flaps depends on an understanding of the penile blood supply. The cross-sectional anatomy of the penis is shown in figure 1. Penile skin flaps depend on the subcutaneous plexus travelling in the tunica dartos just superficial to Buck's fascia. This

plexus is derived from axial penile arteries which arise from the superficial and deep branches of external pudendal artery [Figure 2].

Types of penile skin flaps

Penile skin flaps are described by anatomic classification. As described by Jack McAninch, this classification should define the orientation of the harvested flap (longitudinal vs. transverse), the location where the skin island was derived (proximal vs. distal penile skin), the vascular supply (dorsal vs. ventrolateral pedicle), and how the flap is incorporated into the urethra (onlay vs. tube vs. combined tissue transfer)^[17]. In addition to the anatomic description, the flap is also often described in the literature based on the eponym of the describing surgeon. For example, the longitudinal ventral penile skin flap with lateral pedicle placed as a ventral onlay is also referred to as the “Technique of Orandi” or “Orandi Flap”^[27,28]. Further confusion can arise with modifications of classic descriptions, such as a tubularized “modified Orandi Flap”^[29]. It is therefore important to adhere to the anatomic description described above.

Longitudinal Ventral Penile Skin Flap with Lateral Pedicle (Orandi Flap)^[28]

With the penis on stretch a vertical, ventral penile shaft incision is made over the strictured area that corresponds to the approximate stricture length [Figure 3]. This incision should be carried lateral to the corpus spongiosum and will be the deep incision for flap harvest. On the contralateral side a lateral urethrotomy is made until there is normal urethral mucosa is encountered at the proximal and distal aspects of the urethrotomy. A skin island is then dissected to match the urethrotomy defect. The superficial incision is then made to and carried laterally to release the skin island and allow for suturing of the flap to the urethrotomy in a tension-free anastomosis [Figure 4].

Longitudinal Ventral Penile Skin Flap with Ventral Pedicle (Turner-Warwick Flap)^[30]

Similar to the Orandi technique this is a skin island flap derived from ventral skin. The Turner-Warwick differs in that the pedicle is derived from bilateral ventrolateral arteries and used mostly in the bulbar urethra. Often the skin marking is made after perineal dissection and

characterization of the bulbar urethral stricture. The deep plane of the skin island is developed distally and the superficial layer is developed at the proximal flap apex. The island and pedicle are then raised and inverted through the scrotal tunnel and out the separate perineal incision to be incorporated into the bulbar urethra [Figure 5]. This technique has been described most in modern literature as part of augmented anastomotic urethroplasty

Ventral Transverse Penile Island Flap with Ventral Pedicle (Jordan Flap)^[31]

Similar to the Orandi and Turner-Warwick flaps this technique isolates a distal penile skin flap from ventral penile skin. The pedicle is derived from bilateral ventrolateral arteries similar to the Turner-Warwick. This technique is utilized in distal penile and fossa novicularis strictures and differs from other techniques with a broader pedicle and comparatively smaller skin island. Like other techniques this is anastomosed to the distal ventral urethra.

Transverse Circular Penile Skin Flap with primary Dorsal Pedicle (McAninch Flap)^[32]

With the penis on stretch a circumferential skin flap (width 2-2.5cm based on stricture caliber) is taken from the distal penile skin or inner prepuce [Figure 6-7]. The distal aspect of the flap should be dissected deep to the pedicle leaving the pedicle with the proximal skin island. The entire penile shaft should be degloved in this deep plane (superficial to Bucks fascia). The proximal skin incision is then made superficial to the pedicle creating a circumferential skin island which can be divided dorsally or ventrally to be rotated 90 degrees for urethral incorporation [Figure 8-10]. The flap is traditionally divided ventrally. Additional length can be generated in this technique by modifying the circumferential incision into a Q incision.

Single-stage vs. Two stage

One of the benefits of penile skin flaps for urethral reconstruction is the adaptability to achieve adequate urethral patency in a single stage. For complex stricture disease, a two-stage repair may be required. In non-randomized series there is a lower re-stricture rate with 2-stage procedures, however, there is a higher surgical revision rate^[33]. Two-staged procedures should be considered

in cases where single-staged options would have an unacceptable risk of recurrence. Specifically, American Urological Association (AUA) guidelines recommend against single-stage tubularized graft urethroplasty due to high recurrence rate and alternatives - including staged repair - should be pursued^[34,35].

CONCLUSION

Anterior urethral reconstruction requires a detailed understanding of patient disease, penile anatomy and multiple operative approaches. Though some reviews have suggested improved patency rates with BMG compared to penile skin flaps^[8], many of these studies have shorter follow up for BMG and multiple randomized studies have not shown a benefit of one technique over another. While flaps have fallen out of favor as a mainstream reconstructive option in favor of BMG, penile skin flaps continue to play an important role in urethral reconstruction particularly in the penile urethra in appropriately selected patients.

DECLARATIONS

Authors' contributions:

Manuscript draft, literature review: Shaw NM

Manuscript draft, editorial corrections: Amend G

Manuscript draft, conception and design: Breyer BN

Availability of data and materials

Data not included in the review can be made available on request.

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Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

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Figure Legend

Figure1-10

Figure 1: Fascial anatomy of the penis

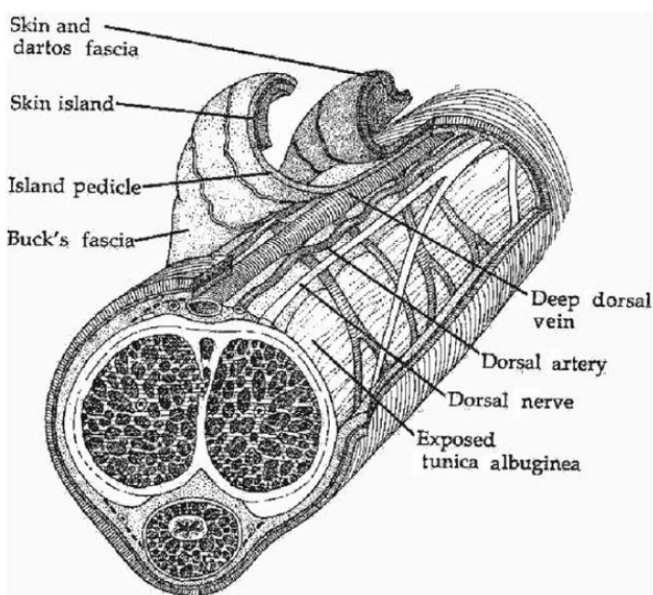


Figure 1: Fascial Anatomy of the penis

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Figure 2: Artery supply and venous drainage of the penis

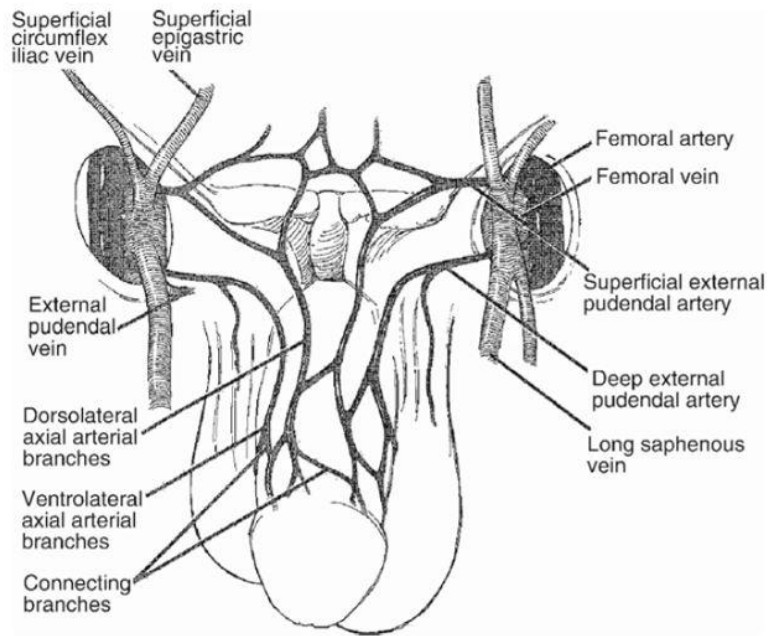


Figure 2: Artery supply and venous drainage of the penis
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Figure 3: Technique of harvest of the Orandi Flap

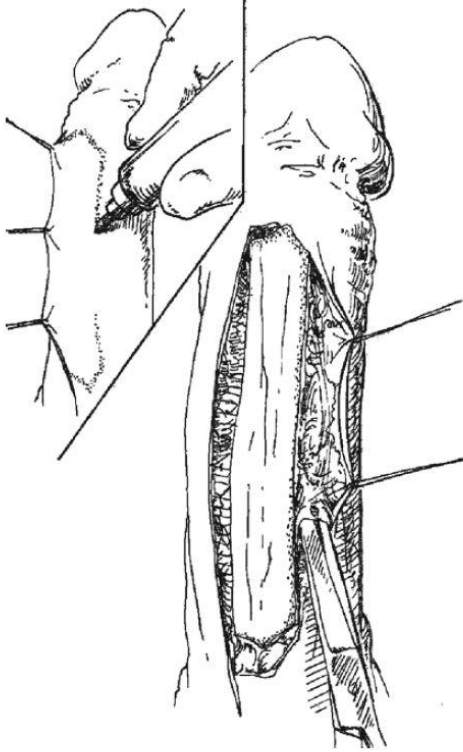


Figure 3: Technique of harvest of the Orandi Flap
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Figure 4: (a) Rotation and onlay anastomosis of the Orandi flap. (b) Orandi skin flap sewn to urethral plate. Foley catheter then placed and contralateral side of the flap anastomosed

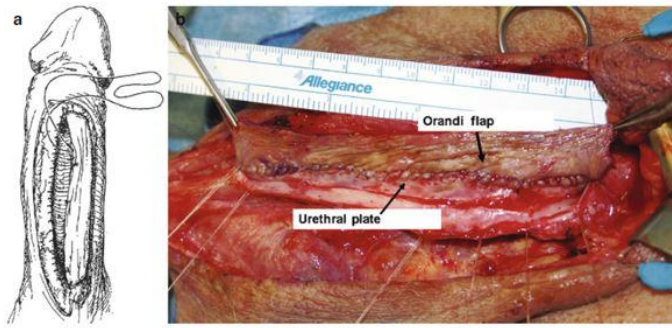


Figure 4: (a) Rotation and onlay anastomosis of the Orandi flap. (b) Orandi skin flap sewn to urethral plate. Foley catheter then placed and contralateral side of the flap anastomosed (Image courtesy of SB Brandes)
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Figure 5: Technique of harvest of the Turner-Warwick flap (a-c) development of pedicles skin flap, (d) sewing the flap to urethral plate

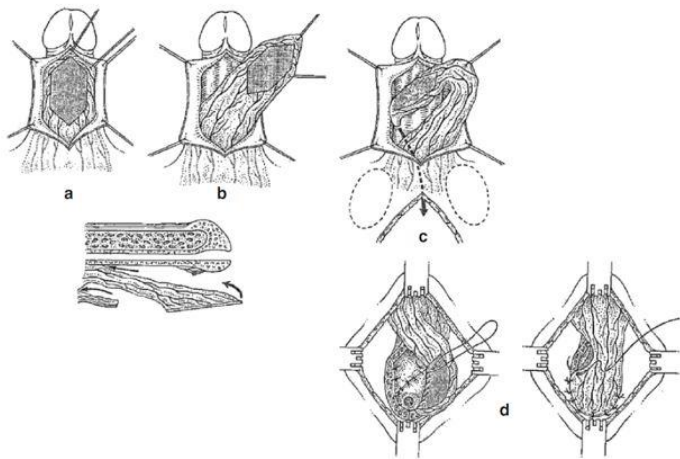


Figure 5: Technique of harvest of the Turner-Warwick flap (a – c) development of pedicles skin flap, (d) sewing the flap to the urethral plate
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Figure 6: Skin markings for flap harvest



Figure 6: Skin markings for flap harvest (Figure copyright Jack W. McAninch, MD, illustration by Stephan Spitzer)

Figure 7: Technique of harvest of the McAninch Flap

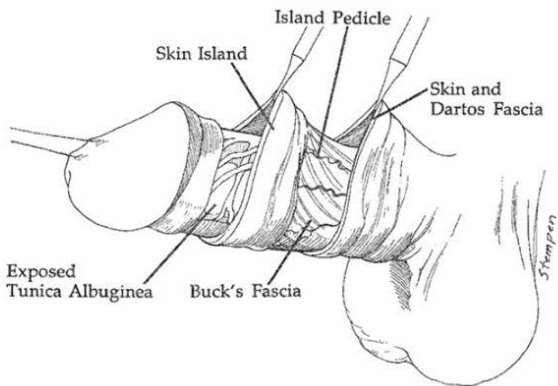


Figure 7: Technique of harvest of the McAninch flap (Figure copyright Jack W. McAninch, MD, illustration by Stephan Spitzer)

Figure 8: Ventral division of the skin island and pedicle in the midline

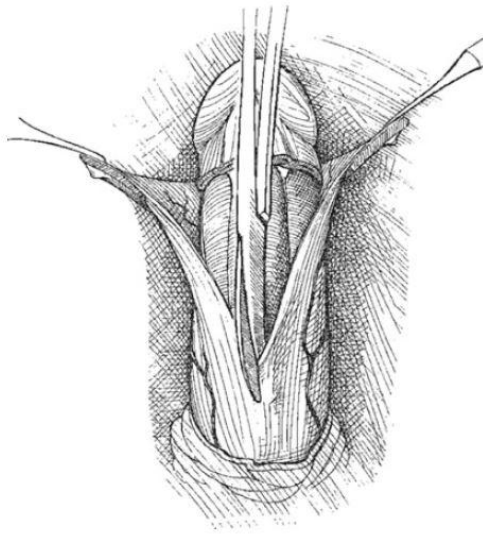


Figure 8: Ventral division of the skin island and pedicle in the midline
(Figure copyright Jack W. [McAninch](#), MD, illustration by Stephan Spitzer)

Figure 9: 90 degree flap rotation and ventral transposition

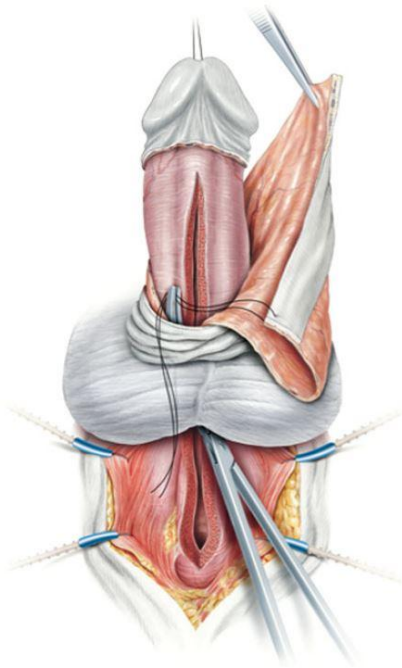


Figure 9: 90° flap rotation and ventral transposition
(Figure copyright Jack W. [McAninch](#), MD, illustration by Stephan Spitzer)

Figure 10: Onlay anastomosis of the McAninch flap

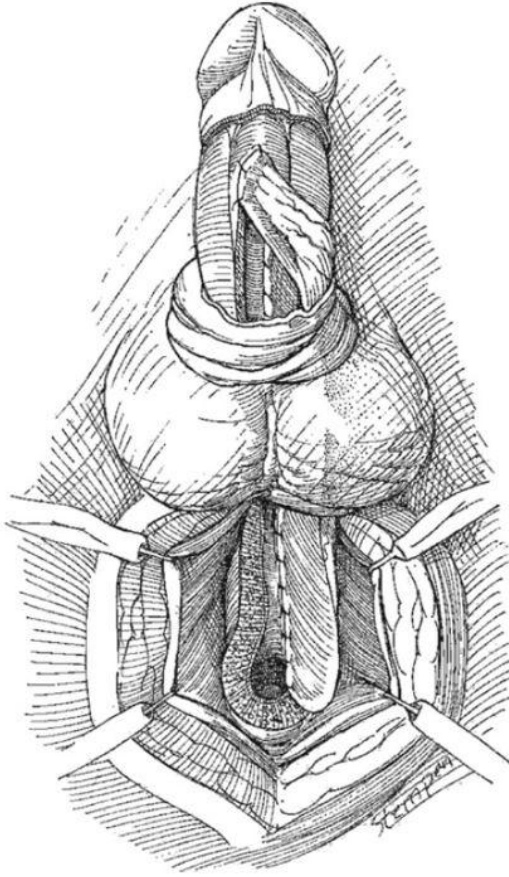


Figure 10: Onlay anastomosis of the McAninch flap
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Table 1: Selection of published success rates for penile skin flaps in urethral reconstruction.
 Comments focus on unique features of the study included.

Technique	Authors	Year	Patients	Success	Comment
Penile circular fasciocutaneous flap urethroplasty (McAninch Technique)	McAninch ^[32]	1993	10	100%	Relatively short follow up (14m). Proof of concept
	McAninch & Morey ^[34]	1998	66	79%	Lower success with tubularized flap

					(58%)
	Alsikafi <i>et al.</i> ^[12]	2005	24	84%	48 month follow up. No significant difference compared to buccal grafting (non-randomized)
	Dubey <i>et al.</i> ^[14]	2007	28	85.8%	Randomized to skin flap vs buccal mucosal graft. No sig difference in recurrence. PROMs favored BMG.
	Whitson <i>et al.</i> ^[4]	2008	124	79%	Success at 1 year (95%) declined over 10 year follow up (79%). Smoking, prior hypospadias, and long strictures (7-10cm) predictive of failure.
	Kim <i>et al.</i> ^[36]	2014	29	69.9%	Included combined tissue transfer
Longitudinal ventral penile skin flap with lateral pedicle (Orandi Technique)	Orandi ^[28]	1972	21	95%	Proof of concept.
	Goel <i>et al.</i> ^[27]	2015	10	80%	4 year follow up. Small sample size.

	Hmida <i>et al.</i> ^[37]	2019	77	88%	Younger age (45) than most studies. All recurrences managed with DVIU
	Ali <i>et al.</i> ^[38]	2019	42	85.7%	Randomized to skin flap v buccal dorsal onlay. No statistical differences. Short follow up (~12 months)
	El-Kassaby <i>et al.</i> ^[39]	2021	34	88%	Average length <1cm penile strictures.
Transverse Ventral Penile Skin Flap with Ventral Pedicle (Jordan Technique)	Virasoro <i>et al.</i> ^[40]	2007	35	83%	Fossa novicularis strictures. Included LS patients with lower success (50%). Extensive follow up (10 years).