Demzik *et al. Plast Aesthet Res* 2020;7:52
DOI: 10.20517/2347-9264.2020.93

Plastic and Aesthetic Research

Review

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Skin grafting for penile skin loss

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How to cite this article: Demzik A, Peterson C, Figler BD. Skin grafting for penile skin loss. *Plast Aesthet Res* 2020;7:52. http://dx.doi.org/10.20517/2347-9264.2020.93

Received: 24 Apr 2020 **First Decision**: 11 Aug 2020 **Revised**: 1 Sep 2020 **Accepted**: 17 Sep 2020 **Published**: 12 Oct 2020

Academic Editor: Marlon E. Buncamper **Copy Editor**: Cai-Hong Wang **Production Editor**: Jing Yu

Abstract

Penile skin grafting is an effective technique for managing skin deficiency resulting from a variety of causes. A thorough understanding of penile anatomy and the pathophysiology of the underlying condition being treated are essential. We provide an overview of penile anatomy as well as the pathophysiology of conditions that may lead to penile skin deficiency, as a result of either the underlying condition or its management. The conditions discussed include lichen sclerosus, buried penis, hidradenitis suppurativa, lymphedema, necrotizing fasciitis, cancer, and trauma. We also discuss surgical technique for penile skin grafting with an emphasis on technical considerations unique to the penis. Finally, we review the available literature on penile skin grafting.

Keywords: Skin grafting, penile reconstruction, buried penis, hidradenitis suppurativa, Fournier gangrene, penile lymphedema, penile cancer, penis, lichen sclerosus et atrophicus

INTRODUCTION

Penile skin grafting is an effective technique for managing skin deficiency resulting from a variety of causes, including trauma, infection/inflammation, surgery, and cancer treatment. A thorough understanding of penile anatomy and the pathophysiology of the underlying condition being treated are essential to achieving acceptable functional and aesthetic results. In this review, we provide an overview of penile anatomy as well as the pathophysiology of conditions that may lead to penile skin deficiency, either as a result of the underlying condition or its management. We also discuss surgical technique for penile

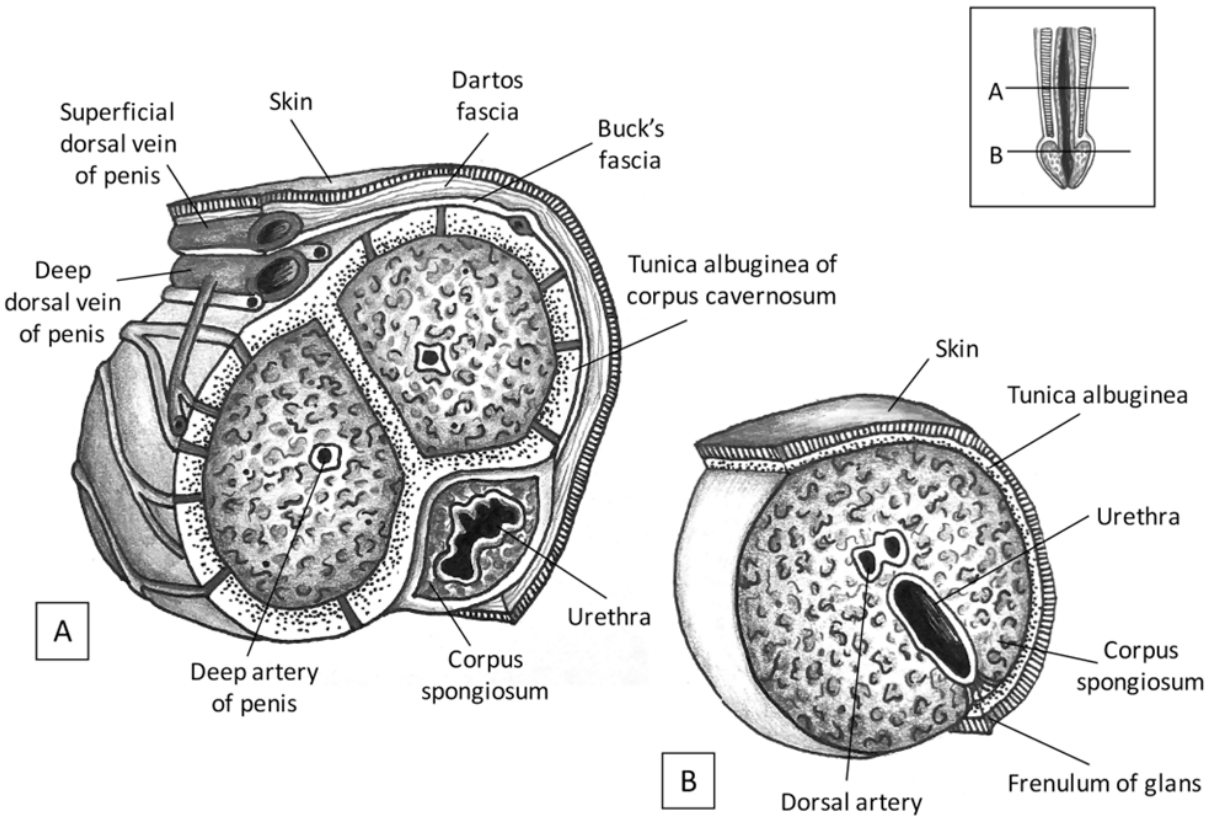

Figure 1. Penis cross sectional anatomy: (A) penile shaft and (B) penile glans

skin grafting with an emphasis on technical considerations unique to the penis and review the available literature on penile skin grafting.

PENILE ANATOMY

The penis consists of paired erectile bodies (corpora cavernosa) and the urethra, which is surrounded by the corpus spongiosum [Figure 1]. Distally, the corpus cavernosa terminate, and the corpus spongiosum expands to form the glans penis. Each corpus is surrounded by tunica albuginea, a tough fibrous connective tissue. In the shaft of the penis, all three corpora are surrounded by Buck's fascia - a dense non-mobile fascial layer that is in continuity with the deep suspensory ligament of the penis and anterior rectus fascia in the abdominal wall. Dorsally, the artery, veins, and nerves for the glans traverse longitudinally along the penis deep to Buck's fascia. Dartos fascia, which is a loose areolar layer in continuity with Scarpa's fascia of the abdominal wall, is superficial to Buck's fascia and allows for movement of the penile shaft skin relative to Buck's fascia and the deeper penile structures. Dermal adhesions in the distal penile shaft skin result in a fold that allows the preputial skin to drape over the glans penis. The tunica albuginea of the glans penis is covered by a thin densely adherent layer of skin with no underlying fascia.

The common penile artery, which is the terminal branch of the internal pudendal artery, divides into the bulbourethral artery (which supplies the corpus spongiosum and glans penis), the cavernosal arteries (which supplies the corpora cavernosa), and the dorsal artery (which supplies the glans penis). Dartos fascia and skin are supplied by the superficial external pudendal artery (a branch of the femoral artery). The superficial and deep arterial systems communicate at the coronal sulcus. Following circumcision, the remaining preputial skin is supplied by Dartos fascia that was not divided during the circumcision and from retrograde flow from the glans. Venous drainage in the penis mirrors the arterial supply. Lymphatic drainage occurs via the superficial inguinal lymph nodes.

PATHOPHYSIOLOGY

Successful management of penile skin deficiencies requires a thorough understanding of the underlying disease process. Common causes of penile skin loss and scarring are summarized below.

Lichen sclerosus

Lichen sclerosus (LS) is a chronic, inflammatory condition of unknown etiology that results in scarring and contraction of the affected tissue. In men, LS typically involves the prepuce and skin of the glans but can also extend to the penile shaft skin and urethra. Scarring and contracture of this tissue can result in difficulty with urination, sexual function, and exposure of the penis. Malignant transformation is estimated to occur in 2%-8% of cases[1], thus it is essential to ensure that patients with LS can adequately expose and monitor the penis for malignant changes. While there is no cure for LS, topical steroids may halt progression of the disease and resolve symptoms such as itching, burning, and pain related to inflammation[2]. Pain, urinary obstruction, and sexual dysfunction related to scarring and contracture of the penile or peri-penile tissues should be managed with excision of the affected tissue. In un-circumcised men with phimosis, circumcision alone is typically sufficient. In circumcised men, skin grafting is typically necessary.

Buried penis

The term "buried penis" is vague but typically refers to a condition in which a prominent mons pannus hangs over the genital skin, causing inflammation and scarring/contracture of the penile and adjacent skin (stage "2b" in a classification system proposed by Tausch *et al.*[3]). In these cases, treatment involves panniculectomy to remove the source of inflammation, removal of the diseased and contracted penile shaft skin, and skin grafting of the resulting defect[4].

Hidradenitis suppurativa

Hidradenitis suppurativa is a chronic inflammatory disease of hair follicles. If untreated, follicular inflammation results in hyperkeratinization and ultimately occlusion of the hair follicle, resulting in formation of sinus tracts and fistulas within the dermis. In severe cases, chronic inflammation and infection of the dermis lead to abscess formation and scarring/contracture of the surrounding skin. Mild cases can be treated with topical and/or intralesional therapy, whereas severe cases require excision of the scarred and chronically inflamed skin[5].

Lymphedema

Penile lymphedema occurs as a result of abnormal retention of lymphatic fluid secondary to obstruction. Impaired lymphatic drainage of the penis may be idiopathic or secondary to surgery, malignancy, parasitic infection, or radiation. Early changes include soft, pitting edema. Chronic lymphedema results in inflammation, thickening, and fibrosis of the skin and subcutaneous tissues, which may lead to disfigurement, pain, and urinary or sexual dysfunction. While compression and manual lymphatic drainage may be helpful in managing symptoms of early lymphedema, these techniques are not curative and will not reverse secondary changes such as fibrosis. Restoration of lymphatic drainage with procedures such as lymphaticovenous anastomosis and vascularized lymph node transfer may be useful in certain cases of extremity lymphedema, but they have not proven efficacious for genital lymphedema[6]. The dual lymphatic drainage of the penis allows for treatment of chronic lymphedema with complete debulking of the affected skin and Dartos fascia followed by skin grafting directly to the deeper structures of the penis in order to bypass the obstructed lymphatic system.

Necrotizing fasciitis

Necrotizing fasciitis of the genitals, also referred to as "Fournier's Gangrene", is a rapidly necrotizing infection of the skin and fascia. Predisposing factors include diabetes, alcoholism, immunosuppression,

recent surgical intervention, trauma, and morbid obesity. Infections are frequently polymicrobial, with synergistic involvement of both aerobic and anaerobic organisms found commonly in the perineal and genital area including Clostridia, Klebsiella, Streptococci, Coliforms, Staphylococci, Bacteriodes, and Corynebacteria. Its hallmark is thrombosis of small arteries, which leads to tissue ischemia, necrosis, and further proliferation of the infection[7]. Treatment includes medical management of sepsis (fluid resuscitation and broad-spectrum antibiotics) as well as emergent debridement of affected tissue. In the penis, the process is nearly always limited to skin and fascia so debridement of the corpus cavernosum, corpus spongiosum, and glans penis is not required. Once the affected tissue has been adequately debrided, the infection is controlled, and the patient is stable (usually 48-72 h after initial debridement), reconstruction can occur. While small skin defects can be closed primarily, larger defects require skin grafting.

Cancer

Squamous cell carcinoma is the most common form of penile cancer, representing up to 95% of penile cancer cases. Risk factors include poor hygiene, phimosis, human papillomavirus, and smoking. Treatment options for non-invasive disease include topical therapy and wide local excision. Following excision, small lesions on the penile shaft may be closed primarily while larger lesions will likely require skin grafting. Glans skin is densely adherent to underlying corpus spongiosum and cannot be closed primarily; following excision, these wounds are best managed with skin grafting.

Trauma

Penile skin loss due to trauma is rare, but can occur as a result of burns, animal bites, or farm equipment accidents (e.g., penile skin avulsion from a tractor's power take off mechanism). If the deeper structures of the penis are preserved, the skin deficiency should be treated with skin grafting.

SURGICAL TECHNIQUE

The primary goal of penile reconstruction is to maintain or restore urinary and sexual function with acceptable cosmesis. The penis has several unique anatomic characteristics that should be considered during reconstruction. First, the penis consists of non-hair bearing thin skin that easily translates over the deeper tissues. Second, the penis enlarges with stimulation, requiring elasticity of the penile skin to accommodate the growth. Small wounds can often be closed primarily. Penile wounds that are too large to be closed primarily are best managed with skin grafting.

When possible, healthy Dartos tissue is maintained and used as a graft bed in order to allow for translocation of the penile skin over the deeper structures. In cases of penile lymphedema, it is essential to completely remove Dartos fascia and graft directly to Buck's fascia or tunica albuginea in order to bypass the obstructed lymphatics. While staging is not necessary for most indications, it is preferable when the excised tissue is grossly infected or colonized, such as in hidradenitis suppurativa or necrotizing fasciitis. In these cases, we typically excise the diseased skin, irrigate the wound copiously, secure the skin edges to the base of the penis, and return after one week of wet to dry dressing changes to perform a skin graft.

Various techniques have been used for penile skin grafting, which are summarized in Table 1. Both full thickness skin grafts (FTSGs) and split thickness skin grafts (STSGs), which contain epidermis and a portion of dermis, have been successfully utilized on the penis. STSGs are typically harvested at a depth of 0.012-0.018 inches, with thinner grafts associated with improved graft take.

STSGs are typically harvested from the anterolateral or medial thigh, although STSG can be harvested from the pannus in patients with buried penis[8-11]. Compared to FTSGs, the advantages of STSGs include a thin graft that more closely resembles native penile skin, lack of hair follicles, improved graft take due

Table 1. Published studies with ≥ 10 patients undergoing penile skin grafting since 2005

Author	Years	*n*	Location	Indication	Skin graft	Failure, *n* (%)	Bedrest (days)
Parnham *et al.*[21] (2018)	2005-2016	172	Glans	CA	STSG (0.014-0.018) non-meshed	Partial 29 (17%) Complete 5 (3%)	None
Smith *et al.*[22] (2007)	NR	72	Glans	CA	STSG, non-meshed	Partial: 2 (3%)	4
Pariser *et al.*[17] (2018) *Tang *et al.*[18] (2008)	2007-2017	61	Shaft	BP	STSG (0.012-0.015) fenestrated	NR	2
Hampson *et al.*[19] (2017) Figler *et al.*[4] (2015)	2005-2016	42	Shaft	BP	STSG (0.015) 1:1 meshed or unmeshed	Partial: 6 (14%)	5
Jun *et al.*[16] (2018)	2007-2017	36	Shaft	BP	STSG (0.015) Non-meshed	NR	2
Tausch *et al.*[3] (2016)	2007-2015	31	Shaft	BP	STSG, non-meshed	3 (10%)	NR
Garaffa *et al.*[23] (2011)	1997-2010	31	Glans	LS	STSG (0.00-0.016)	Partial: 1 (3%)	2
Shabbir *et al.*[24] (2011)	2001-2010	25	Glans	CA	STSG (0.008-0.016) non-meshed	1 (4%)	2
Harris *et al.*[25] (2020)	NR	23	Shaft	Pediatrics Exstrophy Epispadias	STSG (0.016-0.018) FTSG, fenestrated	5 (22%)	NR
Cocci *et al.*[9] (2019)	2006-2016	23	Shaft	BP	STSG (0.016 or "thick")	NR	
Figler *et al.*[8] (2020)	2016-2019	19	Shaft	BP	STSG (0.018), non-meshed	0	None
Chertin *et al.*[26] (2016)	NR	17	Shaft	Pediatrics Prior surgery Trauma	STSG (0.012) fenestrated or meshed	1 (6%)	NR
Modolin *et al.*[27] (2006)	NR	17	Shaft	LE	STSG	NR	3
Palminteri *et al.*[28] (2007)	1998-2004	17	Glans	CA, LS	STSG, non-meshed	Partial: 2 (12%)	3
Theisen *et al.*[14] (2018) *Fuller *et al.*[15] (2017)	2015-2017	16	Shaft	BP	STSG (0.016) fenestrated	NR	2
Erpelding *et al.*[13] (2019)	2014-2017	16	Shaft	BP	STSG, meshed	0	None
Monn *et al.*[10] (2019)	2013-2018	13	Shaft	LE	FTSG, non-fenestrated	0	NR
Boonjindasup *et al.*[29] (2016)	2000-2013	11	Shaft	LE, LS Prior surgery	STSG (0.012-0.018) meshed 1.5:1	NR	
Voznesensky *et al.*[11] (2016)	2011-2015	11	Shaft	BP	STSG meshed and non-meshed	NR	2
Thompson *et al.*[30] (2006)		11	Shaft	Pediatrics Prior surgery, LE	FTSG	0	NR
Rybak *et al.*[31] (2014)	2007-2011	10	Shaft	BP	STSG (0.016-0.018) fenestrated	NR	
Hadway *et al.*[20] (2006)	NR	10	Glans	CA	STSG, non-meshed	0	5

*Indicates technique paper. N: number of patients in study with penile skin graft; LE: lymphedema; HS: hidradenitis suppurativa; BP: buried penis; LS: lichen sclerosus; NF: necrotizing fasciitis; CA: cancer

to reduced metabolic requirements, and the ability to easily mesh and expand the graft to cover a larger recipient site. Additional benefits of meshing are preventing accumulation of fluid under the graft (which can interfere with graft take) and easier accommodation of the graft to the contours of an irregular graft bed. In non-meshed STSGs and FTSGs, fluid accumulation under the graft can be achieved by fenestration of the graft with an 11 blade or hollow bore needle. While meshed regions typically heal via epithelial ingrowth from the surrounding skin graft, mesh lines may persist and be aesthetically unpleasing [Figure 2]. When meshing is performed on the penis, it is usually at a ratio of 1.5:1 to 2:1, although the use of non-expanded 1:1 meshing has been suggested as a way to achieve appealing cosmesis while preserving other benefits of meshing[12].

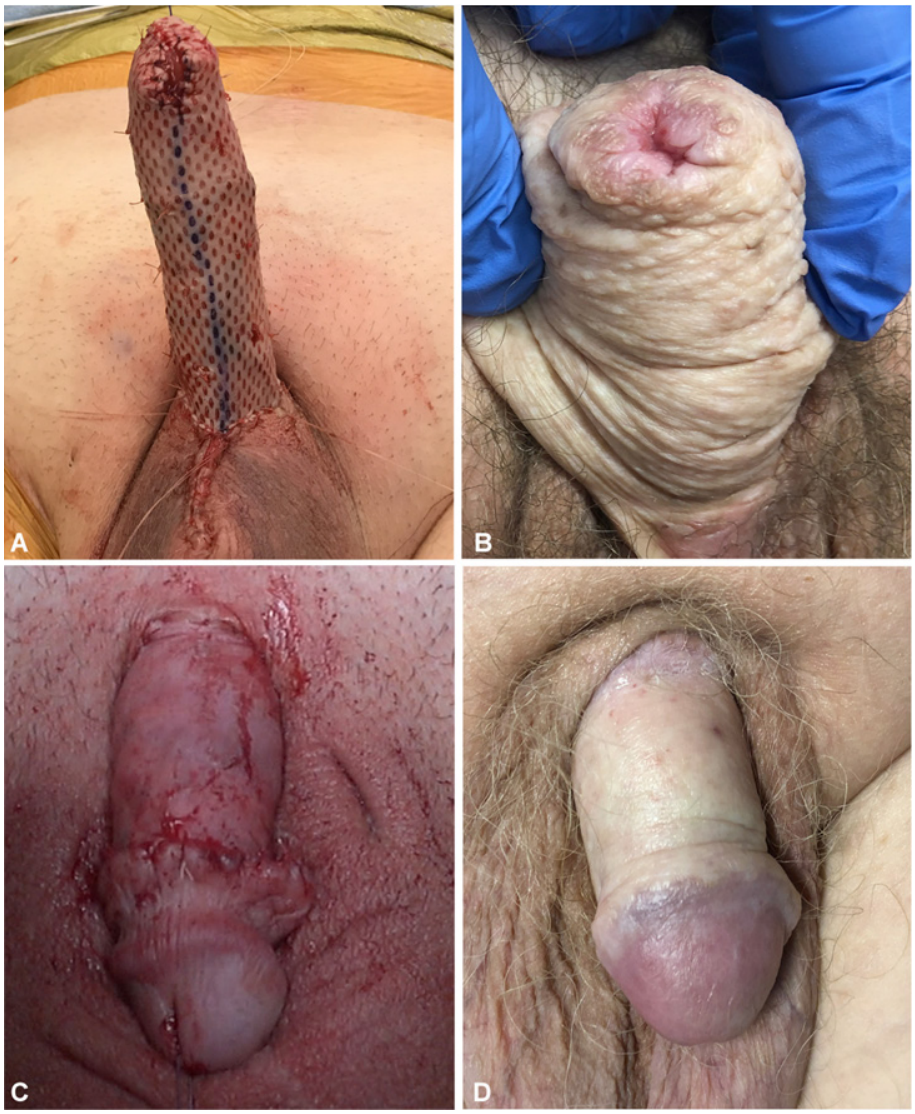

Figure 2. Penile skin grafts at the time of surgery (A,C) and one year postoperatively (B,D) showing smooth appearance of unmeshed graft (D) and stippled appearance of meshed graft (B)

FTSGs are typically harvested from the inguinal region, where large amounts of hairless skin with high elasticity can be harvested relatively easily. Compared to STSGs, FTSGs experience more primary contracture (immediate recoil of elastin fibers in the dermis) and less secondary contracture (delayed shrinkage due to myofibroblast activity). FTSGs typically contain sweat glands, whereas STSGs do not contain sweat glands and require periodic application of a moisturizer or emollient. Since hidradenitis suppurativa results from dysregulation of apocrine glands, STSGs are preferred to FTSGs in these patients.

Immobilization of the skin graft on its bed is essential for graft survival. To avoid sheering or displacement of the graft, many surgeons place patients on 2-7 days of bed rest after a skin graft. However, prolonged bed rest after surgery is associated with an increased risk of deep vein thrombosis, which can lead to pulmonary embolus and death, thus it should be avoided if possible. As a result, recent studies have reported their experience using a bolster dressing without bed rest to immobilize penile skin grafts. These studies have reported excellent outcomes, suggesting that bed rest is not necessary if an appropriate bolster dressing is used after penile skin grafting[8,13]. The use of fibrin sealant to immobilize grafts has also been reported[14-18].

Essential characteristics of penile bolster dressings are the use of non-stick gauze and a mechanism to keep the penis on full stretch so that there is adequate skin during an erection. This can be successfully accomplished by creating a tie-over bolster while the penis is on full stretch, by suturing the dressing to the penis while on full stretch, or by applying a negative pressure dressing while the penis is on full stretch. It is important to keep the graft moist; this can be accomplished with frequent application of a liquid solution (e.g., "sulfamylon slurry") or by soaking the dressing in mineral oil at the time of surgery.

OUTCOMES

Outcomes after penile skin grafting are generally excellent, with partial and complete graft loss occurring in 8% and 3% of patients, respectively [Table 1]. Patient-specific risk factors for poor graft take include obesity, diabetes mellitus/hyperglycemia, poor nutritional status, and the presence of an infected or colonized wound bed. Patients with an infected or colonized wound bed (e.g., those with hidradenitis suppurativa) typically benefit from a staged approach in which the wound is treated with wet to dry dressing changes or negative pressure therapy for 3-10 days before attempting skin grafting[5].

Patient reported outcomes after buried penis repair indicate significant improvement in quality of life. At 13 months follow-up, Theisen *et al.*[14] reported a significant improvement in 10/12 domains of urinary function and 10/13 domains of sexual function. They also reported improvements in overall urinary and sexual bother in 88% and 94% of patients, respectively. At 39 months follow-up, Hampson *et al.*[19] reported improvement in all functional domains that were assessed (ability to see penis, ability to stand to urinate, ability to perform genital hygiene, erectile function, and sexual function). In their series, 85% of patients reported they would undergo buried penis surgery again, 74% that surgery led to a positive change in their lives, and 85% that surgery had remained a long-term success. Voznesensky *et al.*[11] reported similar results: patients reported improvement in hygiene (100%), urination (91%), and sexual function (41%), with 92% of patients reporting that they would choose to have the surgery again and 83% reporting that surgery led to a positive change in their lives. They also found that over 90% of men had lost additional body weight at their last clinical follow-up.

While patient reported quality of life outcomes have not been thoroughly explored after penile skin grafting for other indications, Hadway *et al.*[20] assessed a number of patient-reported quality of life outcomes after glans resurfacing for premalignant lesions. Among seven patients who completed the questionnaires, all seven stated that sensation at the tip of the penis was no different or better after surgery; five felt that their sex life had improved; and two felt it had not changed. All patients rated overall satisfaction as a 4 or 5 on a five-point scale.

CONCLUSION

Penile skin grafting is an effective technique for managing skin deficiency resulting from a variety of causes. With a thorough understanding of penile anatomy and the pathophysiology of the condition being treated, successful outcomes can be reliably achieved.

DECLARATIONS

Authors' contributions

Made substantial contributions to conception and design of the study: Demzik A, Figler BD
Performed data acquisition and provided technical support: Peterson C, Figler BD

Availability of data and materials

Not applicable.

Financial support and sponsorship

None.

Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

A written informed consent to participate in the study was obtained from participants.

Consent for publication

Written informed consent for publication of images was obtained.

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