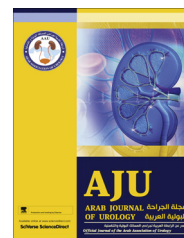




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REVIEW

Penile reconstruction in the male



Giulio Garaffa ^{a,b,c,*}, Vincenzo Gentile ^d, Gabriele Antonini ^d,
Petros Tsafarakidis ^{b,c}, Amr Abdel Raheem ^a, David J. Ralph ^a

^a St Peter's Andrology, University College London Hospitals, London, UK

^b Department of Urology, Broomfield Hospital, Chelmsford, UK

^c Whipps Cross University Hospital, London, UK

^d Department of Urology, University "La Sapienza", Rome, Italy

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KEYWORDS

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ABBREVIATIONS

RAFF, radial artery-based forearm free flap;
STSG, split-thickness skin graft

Abstract We describe and review the most recent techniques of male genital reconstruction, identifying relevant material with an unstructured PubMed-based search of previous reports, using the keywords 'reconstruction', 'glans', 'shaft', 'lymphoedema', 'skin graft', 'scrotoplasty', 'urethroplasty', and 'penile prosthesis'. This search produced 22 reports that were analysed in this review. Split-thickness skin grafts are ideal for glans reconstruction, while full-thickness skin grafts should be used to cover defects on the shaft penis, as they tend to heal with less contracture. The radial artery-based free-flap phalloplasty is the technique of total phallic reconstruction associated with the highest satisfaction rates. Further research is required to identify an ideal reconstructive technique that would guarantee superior cosmetic and functional results, minimising donor site morbidity.

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Introduction

Despite the continuous development of surgical devices and techniques over the past decades translating into a

significant improvement in the outcome of male genital reconstruction, repairing and reconstructing the penis remains anatomically, functionally and aesthetically a great challenge. This is because the primary goal of penile reconstruction surgery is to achieve an adequate result in terms of cosmesis and function, with restoration of the capacity to void while standing from the tip of the phallus and, in the sexually active patient, to engage in penetrative intercourse with an adequate erogenous sensation.

As no other tissue in the body has the ideal characteristics in terms of colour, elasticity and texture to be used

* Corresponding author. Address: St Peter's Andrology, 145 Harley Street, W1G 6BJ, London, UK. Tel.: +44 7983477939.

E-mail address: giulio garaffa@gmail.com (G. Garaffa).

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for male genital reconstruction, preservation of as much viable tissue as possible is always advisable. Therefore, in male genital trauma, surgical repair should be immediate, to maximise the preservation of viable tissue. When genital tissue is not available for repair, skin grafts, and a variety of pedicled and free flaps, represent a viable option for genital reconstruction.

We identified relevant articles published in the last 15 years using an unstructured PubMed-based search, applying the keywords 'glans reconstruction', 'shaft reconstruction', 'lymphoedema of the genitalia', 'skin graft', 'scrotoplasty', 'phalloplasty', 'free flaps', 'urethroplasty', and 'penile prosthesis'.

Glans reconstruction

Reconstruction of the glans penis might be required in isolation, after traumatic amputation or surgical excision for benign and malignant conditions, or as part of a total phallic reconstruction.

Various genital conditions are managed with partial or complete excision of the glans penis, as reported in Table 1. Loss of genital tissue requiring glans reconstruction might also be secondary to traumatic amputation of the distal aspect of the penile shaft.

Glans resurfacing, which involves the partial or complete excision of the glans mucosa followed by repair with the use of a split-thickness skin graft (STSG) of non-genital skin, is indicated if the mucosa of the glans penis is affected by lichen sclerosus or carcinoma *in situ* [1,2].

To render the procedure easily reproducible and to facilitate the work of the histopathologist, the affected epithelium is initially marked in quadrants from the meatus to the coronal sulcus, and perimeatal and circumcoronal incisions made. The glans epithelium and subepithelial tissue are then completely peeled from the underlying spongiosum, using sharp dissection from the meatus to the coronal sulcus for each quadrant. A STSG, usually harvested from the thigh with an air dermatome, is used to cover the 'exposed' spongiosum. The graft thickness is usually 0.2–0.4 mm, to minimise donor-site morbidity and to guarantee adequate cosmetic and functional results. The graft is then quilted using several 5–0 interrupted polyglactin sutures to the spongiosum, to assure an adequate take, and the coronal sulcus is recreated to guarantee an adequate cosmetic result due the rich blood supply to the spongiosum, graft take tends to be complete in all patients. Therefore this

technique yields excellent cosmetic and functional results in almost all patients. [2].

Glansectomy, which involves the complete dissection of the glans penis from the tip of the corpora cavernosa, is indicated for widespread pT1 and pT2 squamous cell carcinoma of the glans penis [3]. The procedure is usually carried out through a circumferential circumcising incision, which is made in the distal shaft skin down to Buck's fascia, and allows the surgeon to develop a plane between the spongiosum and the corporal heads. Once the glans penis is completely lifted up, the urethra is divided. Frozen sections are usually cut from tissue taken from the tunica albuginea and the distal urethral margin to confirm the complete clearance of the malignancy. The shaft skin is then sutured 2 cm proximally from the tip of the corporal heads, and a pseudo-glans is fashioned using a STSG, which is quilted on the corporal heads in an attempt to recreate the normal anatomical appearance of the organ.

If the frozen-section analysis is positive, a distal corporectomy is performed; the excision is progressively carried out more proximally until the tumour is completely cleared. The glans is then reconstructed using the same quilting technique as previously described after a glansectomy.

Glans reconstruction using a STSG, both after glansectomy or distal corporectomy, is simple and reproducible, and yields adequate cosmetic and functional results in almost 99% of patients [4].

Scrotal reconstruction

Contrarily to penile tissue loss, scrotal skin loss, which is usually secondary to Fournier's gangrene, trauma or after excision of bulky penile tumours, does not pose a great challenge for the reconstructive surgeon. This is due to the intrinsic laxity of the scrotal skin, which allows for primary closure even when the skin loss is up to half [5]. When, due to extensive tissue loss, a primary closure is not feasible, the scrotum can be reconstructed using a STSG or local flaps.

After a scrotal trauma with exposure of the testes, preservation of spermatogenesis is the first concern. Therefore the testes should be initially positioned in subcutaneous thigh pouches in preparation for scrotal reconstruction.

Relocation of the testes in the scrotum is supported by concerns about pain, adverse psychological outcomes

Table 1 Surgical procedures that require a partial or complete excision of the glans penis, and their indications.

Procedure	Indication
Glans resurfacing	Lichen sclerosus or carcinoma <i>in situ</i> of the glans penis
Partial glansectomy	Carcinoma of the penis affecting the glans
Total glansectomy	Carcinoma of the penis affecting the glans
Distal corporectomy	Carcinoma of the penis affecting the glans and infiltrating the distal aspect of the corpora cavernosa

and thermoregulation. In particular, spermatogenesis appears to be significantly abnormal after 2 years of follow-up in patients with testicles buried in thigh pouches, suggesting that thigh pouches are not an ideal or definitive solution in patients who wish to preserve fertility [6].

Usually, in the presence of a tunica vaginalis and of granulation tissue, the scrotum is reconstructed using a meshed STSG. The fenestrations of the graft allow a better take, as they allow the drainage of the exudate, and heal forming longitudinal scars that mimic the rugae of the scrotum [7].

Although many authors have successfully used a STSG for scrotal reconstruction, STSG are insensate, demand a long and time-consuming period of wound care, and play no role in the thermoregulation of the scrotal content. Local pedicled flaps should be the preferred option for testicular coverage when the scrotal defect is too large to allow for primary repair, as they are not associated with complications such as maceration, poor take and breakdown secondary to faecal and urinary contamination, which are common when STSG are used.

Although various flaps have been used for scrotal reconstruction, the vertical rectus abdominis myocutaneous flap, despite a significantly higher donor-site morbidity than the other flaps commonly used, yields the best cosmetic and functional results [8].

Penile shaft reconstruction

Partial or subtotal penectomy, traumatic amputations of the penis, micropenis, exstrophy, aphallia or penile agenesis represent the main indications for penile shaft reconstruction. Preservation of as much viable tissue as possible is paramount in all cases, and patients who have had a partial amputation of the penis should be initially offered conservative management, such as division of the suspensory ligament of the penis or excision of the suprapubic adiposity, to maximise the length of the residual penile stump. If these procedures do not translate into an adequate gain in length and the patient remains unable to engage in penetrative sexual intercourse and to void while standing, total penile reconstruction should be offered.

Phallic reconstruction should ideally involve a few easily reproducible surgical stages, and allow for the creation of a cosmetically acceptable sensate phallus with incorporated neourethra and enough bulk to house a prosthetic device to guarantee the rigidity necessary for penetrative intercourse [9,10]. Despite various surgical techniques being described over the past 70 years, none fulfils all the criteria and is currently accepted as the best method [10].

The choice of the reconstructive technique should be tailored to the patient's expectations, body habitus, previous surgical procedures and comorbidities (such as

diabetes, hypertension, dyslipidaemia and obesity) and tobacco consumption.

The development of total phallic construction techniques has paralleled the development of flaps in plastic surgery, and at present more than 20 different types of flaps are available for phallic construction.

After the initial attempt at phallic reconstruction by Bogoras in 1936, Gillies introduced the concept of a 'tube within a tube' incorporating a neourethra in a phallus, which was formed on the abdomen and then transferred in a multi-staged fashion to the recipient area [9,10].

Despite the initially poor results, due to the formation of an insensate and wedge-shaped phallus, infra-umbilical flaps have progressively become more popular. A neourethra made from a pedicled tube of labial skin could be incorporated in the phallus in a one- or two-stage procedure to allow patients to void while standing. In a carefully selected group of patients, this technique yields satisfactory cosmetic and functional results with more than two-thirds of patients fully satisfied with the results of surgery [11].

The use of musculocutaneous thigh flaps based on the gracilis muscle has been dismissed, due to poor cosmetic and functional results secondary to muscular contraction [12].

Microsurgical techniques have revolutionised total phallic reconstruction, and in the early 1980s, Chang and Huang [13] and Song et al. [14] described the use of the radial artery forearm free-flap (RAFF) phalloplasty for total penile reconstruction after amputation. As in the Gillies technique, the reconstructive procedure involved the creation of 'a tube within a tube' using forearm skin, with the urethra fashioned from the relatively less hair-bearing area, and the whole flap based on the radial artery. This technique allowed the creation of a cosmetically acceptable phallus. Sensation was also maintained due to the coaptation of the antebrachial nerves to the dorsal nerve of the penis or to the iliohypogastric and ilioinguinalis nerves.

The main drawback of this technique is donor site morbidity. In an attempt to minimise donor site morbidity, free osteocutaneous fibular flaps, anterolateral thigh flaps and upper-arm flaps have been described, but due to the nature of these flaps, although associated with a lower donor-site morbidity, the cosmesis and function of the neophallus is not as satisfactory as after using the RAFF [15–17].

Patients who wish to void whilst standing, but are not prepared to accept the donor-site morbidity associated with the RAFF, can be offered the incorporation of a 4-cm wide tubularised free-flap based on the radial artery in a pre-fashioned infra-umbilical flap phalloplasty [18].

Although associated with a more severe donor site morbidity the RAFF currently yields the best cosmetic and functional results, according to various reports

(Fig. 1) [19–21]. This procedure involves two or three stages, usually carried out 3 months apart over a period of at least a year.

The first stage consists of creating the phallus, which is transposed to the recipient site with a microsurgical free tissue-transfer technique. The arterial blood supply to the flap is guaranteed by the inferior epigastric artery or the femoral artery. Venous drainage is through the branches of the long saphenous vein, the dorsal penile vein or the pampiniform plexus. Cutaneous and erogenous sensation is instead guaranteed by the anastomosis of the cutaneous antebrachial nerves to the dorsal nerve of the penis, the iliohypogastric and ilioinguinal nerves. The phallic urethra is then anastomosed to the proximal urethral stump, to allow the patient to void and ejaculate from the tip of the phallus. The cosmesis of the phallus is then improved during the second stage with the formation of a pseudoglans using the Norfolk technique, which involves the use of a full-thickness skin graft harvested from a nonhair-bearing area, to create the glans ridge and groove.

A penile prosthesis is implanted at ≈ 1 year after phallic construction, to give enough time to allow cutaneous sensation to develop. This procedure is necessary to guarantee the rigidity required for penetrative sexual intercourse.

Unless the phallus is particularly bulky, a single cylinder of an inflatable penile prosthesis is implanted. Due to the absence of the tunica albuginea in the phallus, the cylinders are housed in a Dacron or Gortex tip to prevent distal erosion and to guarantee anchorage to the pubic bone. If the crura of the corpora are present, they are used to house the rear of the cylinders.

Total phallic reconstruction using the RAFF is a reproducible technique. The most feared complication is acute venous thrombosis of the microsurgical anastomosis, which occurs in $\approx 3\%$ of patients and becomes obvious at 2 to 3 days after surgery, when the phallus appears ‘oozy’ and discoloured, and the pulse becomes progressively weaker and then disappears. Due to its subtle onset, it is invariably recognised too late, when

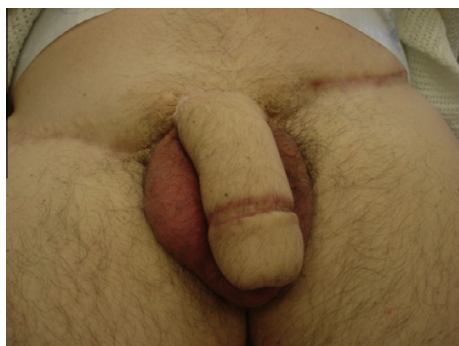


Figure 1 The final result of total phallic reconstruction with the use of the RAFF.

irreversible endothelial changes have already occurred, and therefore leads to the complete loss of the phallus. On the contrary, acute thrombosis of the arterial anastomosis is immediate and easily identifiable. Re-exploration can therefore be immediate and this allows the preservation of the phallus in most cases.

The most common complications after using a RAFF are neourethral stricture and fistulae, which occur, respectively, in $\approx 10\%$ and 20% of cases. However, surgical correction is almost always successful, and up to 99% of patients are able to void while standing, from the tip of the phallus, after revisional surgery [22].

Inserting a penile prosthesis in a phalloplasty is associated with a high risk of complications, with infection, erosion and mechanical failure rates reported, respectively, of up to 11.9% , 8.1% and 22.2% . The overall revision rate can be up to 41% after 4 years. This is due to the presence of the Goretex or Dacron ‘boot and sock’, and to the absence of the tunica albuginea that naturally houses and protects the cylinders.

Despite the higher complication and revision rates, overall, after implanting the inflatable penile prosthesis, up to 60% of patients have a normally functioning erectile device, which can be potentially used to engage in penetrative sexual intercourse [22].

Conflict of interest

None.

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