

Penile Reconstruction with the Radial Forearm Flap: An Update

Penis-Rekonstruktion mit A. radialis-Lappenplastik

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Abstract



Background: Many methods and many free or pedicled flaps have been used in phalloplasty. None of these techniques is able to completely fulfill the well described goals in penile reconstruction. Still, the radial forearm flap is currently the most frequently used flap and thus universally considered the gold standard.

Patients and Methods: Since 1992, we have performed the largest series of 316 radial forearm phalloplasties to date performed by a single surgical team. From these extensive data we critically evaluate how this current supposed gold standard can meet the requirements of an ideal penile reconstruction.

Results: We assessed outcome parameters such as number of procedures to achieve complete functional result, aesthetic outcome, tactile and erogenous sensation, voiding, donor site morbidity, scrotoplasty and sexual intercourse.

Conclusion: While currently no controlled randomized prospective studies are available to prove the radial forearm flap is truly the 'gold standard' in penile reconstruction, we believe that our retrospective data support the radial forearm phalloplasty as a very reliable technique for the creation of a normal looking penis and scrotum. While full functionality is achieved through a minimum of 2 procedures, the patients are always able to void standing, and in most cases to experience sexual satisfaction. The relative disadvantages of this technique are the residual scar on the forearm donor site, the rather high number of initial urinary fistulas, the potential for long-term urological complications and the need for a stiffer or erection prosthesis. From our experience, we strongly feel that a structured multi-disciplinary cooperation between the reconstructive-plastic surgeon and the urologist is an absolute requisite to obtain the best possible technical results.

Zusammenfassung



Einleitung: Viele Methoden und viele freie oder gestielte Lappenplastik werden zur Phalloplastik eingesetzt. Keine dieser Techniken kann die gut definierten Zielvorgaben der Penisrekonstruktion vollständig erfüllen. Bis heute ist die A. radialis-Lappenplastik der am häufigsten genutzte Lappen und wird generell als Gold-Standard angesehen.

Patienten und Methoden: Mit 316 radialen Unterarm Phalloplastiken seit 1992 präsentieren wir die umfangreichste Serie, die bis heute von einem einzelnen chirurgischen Team durchgeführt wurde. Anhand dieser umfangreichen Daten beurteilen wir kritisch, in wie weit der aktuelle Gold-Standard die Erfordernisse einer idealen Penis-Konstruktion erfüllt.

Ergebnisse: Wir bewerteten die folgenden Outcome Parameter: erforderliche Anzahl chirurgischer Interventionen bis zur vollständigen Funktionalität, ästhetisches Ergebnis, taktiles und erogenes Empfinden, Harnentleerung, Morbidität an der Donorseite, Skrotoplastik und Geschlechtsverkehr.

Schlussfolgerung: Obschon es aktuell keine randomisierten kontrollierten Studien gibt, die beweisen dass, die A. radialis-Lappenplastik tatsächlich der Gold-Standard zur Penis-Rekonstruktion ist, unterstützt unsere retrospektive Datenanalyse unserer Meinung nach, das die radiale Unterarm Phalloplastie eine sehr zuverlässige Technik zur Bildung eines normal aussehenden Penis und Skrotums ist. Volle Funktionalität wird durch ein Minimum von 2 Operationen erreicht, die Miktion ist stehend möglich, und zumeist kann auch sexuelle Befriedigung erlebt werden. Die relativen Nachteile dieser Technik sind die zurückbleibende Narbe am Unterarm, die eher hohe Anzahl initialer Harnfisteln, die Möglichkeit langwieriger urologischer Komplikationen und der Bedarf eines Versteifers oder einer Erektionsprothese. Unserer Erfahrung nach ist eine strukturierte multidisziplinäre Kooperation zwischen dem rekonstruktiv-plastischen Chirurgen und den Urologen eine absolute Voraussetzung, um bestmögliche technische Ergebnisse zu erzielen.

Introduction

Phalloplasty is one of the greatest challenges in genitourinary surgery. Reconstructive surgeons have, throughout the ages, been confronted with the unique anatomy and functionality of the penis. Ambroise Paré constructed a penile prosthesis in wood and metal to allow voiding while standing [1]. The first attempts at total penile reconstruction were made in 1936 by Bogoras [2,3]. The tube within a tube concept for creating a neourethra within the penile shaft was first described by Gilles in 1948 [4]. His techniques were subsequently adapted and refined by others [5–7]. These reconstructions consisted of complex and multi-stage procedures using tubed skin flaps or pedicled myocutaneous flaps. The evolution of microsurgical techniques allowed for free tissue transfers with selection of reliable, sensate and minimal hair-bearing tissue for phallic reconstruction. However, the construction of a penis remains a challenging operation, in various trauma or congenital settings, but even more so in a female-to-male (FTM) transsexualism because of the additional need for vaginectomy, scrotoplasty and reconstruction of the horizontal part of the urethra.

From this historical experience, a number of *ideal goals* in performing a phalloplasty have been well described. These include mainly the construction, in a one-stage procedure, of an aesthetic penis with erogenous and tactile sensation, which enables the patient to void while standing, and to have sexual intercourse [8,9]. Furthermore, the genital reconstruction should equally result in a normal scrotum and be reproducible without functional loss or disfigurement in the donor area. It is generally accepted that, to date, these ideal goals cannot all be met, and conversely, it is still unclear what currently can be realistically expected after a state-of-the-art phalloplasty.

The multitude of free flaps that have been described indicates that none of these is really ideal [8, 10–20]. Still, the *radial forearm flap* is by far the most frequently used flap and is universally considered as the ‘gold standard’ in penile reconstruction [8,21–23].

In this article we present the largest series to date of radial forearm phalloplasties performed by a single surgical team. The main purpose of this clinical retrospective study is to evaluate to what extent this supposed gold standard technique is able to approximate the criteria of ideal penile reconstruction.

Patients, Material and Methods

Between 1992 and 2010, 316 consecutive phalloplasties have been performed using a radial forearm flap, for the most part (306/316) in female-to-male (FTM) transsexuals (● **Table 1**).

Between 1992 and 1997, in the early years of this series, a “one-stage” surgical intervention (n=59) was the procedure of choice. This included a subcutaneous mastectomy (SCM), a lower-abdominal hysterectomy and ovariectomy, and a complete genitoperineal transformation, all performed during one surgical intervention. Between 1997 and 2001, the SCM was performed separate as an initial procedure (n=62). From 2001 on (n=195), the SCM was combined with a totally laparoscopic hysterectomy and ovariectomy (TLHO).

For the genitoperineal transformation 2 surgical teams operate simultaneously. The urologist performs a vaginectomy, reconstructs the fixed part of the urethra in combination with a scrotoplasty, thus preparing the acceptor area for the free flap. At the same time, the plastic surgeon dissects the radial forearm flap and constructs a tube-within-a-tube phallus [17] while the flap is still pedicled to the forearm. A glans is created with a small skin flap and a full thickness skin graft (● **Fig. 1**). Once the receptor vessels are dissected in the groin, the free flap is transferred to the pubic area. In the first 50 patients of this series, the defect on the forearm was covered with full-thickness skin grafts taken from the groin crease. In subsequent patients we used split-thickness skin grafts harvested from the thigh.

The radial artery is microsurgically connected end-to-side to the common femoral artery and the venous anastomosis is performed between the cephalic vein (which also drains the deep system) and the greater saphenous vein. One forearm nerve (antebrachial cutaneous nerve) is connected to the ilio-inguinal nerve for protective sensation and the other nerve to one of the dorsal clitoral nerves for erogenous sensation. The clitoris is de-epithelialized and buried underneath the penis, just above the pubic bone symphysis.

All patients receive a suprapubic urinary diversion postoperatively. The transurethral catheter is usually removed after 8 days and voiding starts after 12 days.

Table 1 Indications for penile reconstruction (n=316).

female-to-male transsexualism: 306 (96.8%)
penile aplasia: 4 (1.2%)
post-traumatic: 3 (0.9%)
after oncological resection: 1 (0.31%)



Fig. 1 Intraoperative view of penile reconstruction with a radial forearm flap: **a** flap still attached to the arm and **b** at the end of the operation.



Fig. 2 After tattooing of the glans of the penis.

Tattooing of the glans can be performed after a 2 to 3 month period, before sensation returns to the penis (● **Fig. 2**). Implantation of erection and/or testicular prostheses is performed after a 12-month period when protective sensation has returned to the tip of the penis.

The need for regular urological check-up in all these patients allowed for systematic long-term follow-up by all team members (psychiatrist, gynecologist, endocrinologist, and plastic surgeon).

We investigated whether the radial forearm phalloplasty is truly the golden standard in phalloplasty, by evaluating our clinical data according to the ideal goals for penile reconstruction. (i) Can the complete penile reconstruction be performed in one single operation? (ii) Does this technique result in an aesthetically looking penis? (iii) What are the results for the construction of a scrotum? (iv) How is the tactile and erogenous sensation postoperatively? (v) Can the patients void while standing with the reconstructed penis? (vi) What is the overall morbidity of this surgical intervention? (vii) What is the residual functional and aesthetic damage at the donor site of the arm? (viii) Can the patients experience sexual satisfaction postoperatively?

Results

The average hospital stay was 2 and a half weeks (ranges: 16 days–41 days). The complications are described in ● **Table 2**. 36 patients (36/316 or 11.3%) required early anastomotic revision because of an arterial thrombosis ($n=6$), a venous thrombosis only ($n=12$) or a combination of both ($n=18$). In all revisions an arterial-venous fistula was constructed at the distal end of the penis to improve venous outflow [21].

There was a complete flap loss in 3 patients (all older and heavy smoking patients). Superficial skin slough occurred in 19 patients (19/316 or 6%). All wounds were managed conservatively. Partial flap loss with some full-thickness skin necrosis in the distal part of the flap ($<10\%$) was seen in 23 patients (23/316 or 7.2%). An additional surgical procedure (debridement, secondary closure or skin grafting) was required in 15 of the 23 patients (65%). 3 patients developed a (minor) pulmonary embolism. There was a partial non-take of the skin graft at the arm in 13 patients with 9 of them requiring a small re-grafting procedure.

Table 2 Complications.

1) Flap Related:
– anastomotic revision: 36/316 (11.3%)
– complete flap loss: 3/316 (0.9%)
– marginal partial necrosis: 23/316 (7.2%) with 15 additional surgeries
2) Urological:
– early fistula (closing spontaneously) 53/316 (16.7%)
– stricture treated conservatively 20/316 (6%)
– fistula and/or stricture requiring urethroplasty 54/316 (17%) with a total of 101 additional surgeries
3) Erectile prosthesis (on 143 prostheses)
– revision surgery 59/143 (41%)
– incapacity of sexual intercourse: 29/143 (20%)
4) Various
– (minor) pulmonary embolism 3/316 (0.9%)
– re-grafting of defect on arm 9/316 (2.8%)
– nerve compression (early cases) 2/316 (0.6%)
– delayed wound healing in groin/genital area 33/316 (10.4%) with 4 additional surgeries

Minor wound healing problems in the groin or lower abdominal area were observed in 33 patients and these healed with conservative means in most of the cases (29/33).

2 (early) patients demonstrated symptoms of nerve compression in the lower leg due to prolonged gynecological positioning. Urological complications were seen in 40% of the patients (127/316) with a fistula in 80, a stricture in 20 and a combination of both in 27. The majority (53/80) of the fistulas closed spontaneously and many strictures (especially at the meatus) could be managed with dilatation only. In the other patients ($n=54$) a secondary or even tertiary urethroplasty procedure was necessary. In 54 patients a total of 101 procedures were needed to obtain an unobstructed urethra.

In 143 patients an erectile device was implanted. Different types of prostheses have been used. In 9 patients a Dynaflex® (AMS®) was implanted, in 71 an AMS CX®, in 57 an Ambicor® (AMS®) and a Mentor® prosthesis (Porges®, France) in 6 patients. With a mean follow-up of 21.1 months, the original implant was in place in 85 of the 143 implanted patients (59.4%) or 85/316 (26.8%) for the entire group. 59 patients (41.2%) needed to undergo removal or revision surgery due to infection or erosion (19 patients, 13.2%) or dysfunction or leakage (40 patients, 30.8%). The results are the best for the Ambicor group [25]. Despite this high explantation rate, the implantation of an erectile device still is the only viable option allowing an FM transsexual to have satisfactory intercourse.

An evaluation of the aesthetic aspect of the penis was judged almost consistently as better by the patient compared to the surgeon or an independent observer [26].

For a more elaborate description of the outcome parameters we refer to the previously published articles on urological aspects [27], on sexual and physical health [28], on long-term psychological follow-up [29], on genital sensitivity [30], on 2-stage versus one-stage surgery [31], on radial forearm phalloplasty [32], on erectile prosthesis [25, 32], on donor site morbidity [26] and on scrotoplasty [33].

Discussion

The ideal goals in penile reconstruction are well described [8, 9] but the multitude of phalloplasty techniques implies that none



Fig. 3 Long-term aspect of radial forearm phalloplasty (a, b).



Fig. 4 Novel scrotoplasty technique: a before and b after implantation of erection and testicular prostheses.

of them yet meets these ideal requirements. Most surgeons agree that only free flap techniques lead to the best possible functional and aesthetic outcome in penile reconstruction [8, 11, 16, 19, 20, 34, 35]. Pedicled flaps, like the anterolateral thigh flap can, however, be preferred in the case of uncertain pelvic vasculature and anatomy, because they import vascularization from outside the pelvic area. The radial forearm flap is used in up to 90% of all published phalloplasties and is universally considered as the best flap for penile reconstruction [10, 18, 21, 23, 36]. In this retrospective clinical study, describing the largest series to date of 316 radial forearm phalloplasties performed by the same team of surgeons, we evaluate to what extent this supposed gold standard technique (in our hands) has been able to meet the ideal goals in phallic reconstruction.

We agree with Hage [9] who indicated that a complete penile reconstruction with erection prosthesis can never be performed in one single operation. An erection prosthesis can only be correctly placed when the penile flap is fully healed and taken on its final size.

Early in this series, in order to reduce the number of surgeries, we performed an 'all-in-one' procedure which included an SCM and a complete genitoperineal transformation. Later in our series we performed the SCM first and more recently in combination with a TLHO. The reason for changing our protocol was that lengthy operations (>8h) resulted in considerable blood loss

and increased operative risk [31]. Moreover, an aesthetic SCM is not an easy operation and should not be performed 'quickly' before the major phalloplasty operation [37].

To construct an aesthetic penis, it is essential to use a technique that is reliable and reproducible with minimal complications. In this respect, the radial forearm flap has several advantages: this reliable flap is thin and pliable always allowing the construction of a normal sized, tube-within-a-tube penis. To further increase the aesthetic aspect a glans-plasty is performed often in combination with a tattooing of the glans at a later stage (• Fig. 2). The final aesthetic outcome of a radial forearm phalloplasty is a subjective determination, but the ability of most patients to shower with other men or to go to the sauna is the usual aesthetic barometer (• Fig. 3). For a more extensive description of patient and surgeon satisfaction, we refer to our previously published articles [25, 26, 28–30]. In most cases the outcome was seen as more aesthetic by the patient compared to the surgeon or an independent observer [26]. The potential drawbacks of the radial forearm flap are the need for a rigidity prosthesis and possibly some volume loss over time.

The goal of creating natural-appearing genitals also applies to the scrotum. Previous approaches left the labia in situ, with mid-line closure and prosthetic implant filling, or brought the scrotum in front of the legs using a V-Y plasty. These techniques were



Fig. 5 Long-term aspect of the donor site on the forearm.

aesthetically unappealing and reminiscent of the female genitalia.

For the past 7 years, we have employed a novel scrotoplasty which combines a V-Y plasty with a 90° turning of the labial flaps resulting in an anterior transposition of labial skin (◉ Fig. 4). The excellent aesthetic outcome of this male-looking scrotum, the functional advantage of fewer urological complications and the easier implantation of testicular prostheses make this the technique of choice [33].

The recovery of tactile and erogenous sensation in the reconstructed penis is crucial. Of the various flaps used for penile reconstruction, the radial forearm flap has the greatest sensitivity [38]. We always connect one antebrachial nerve to the ilio-inguinal nerve for protective sensation and the other forearm nerve with one dorsal clitoral nerve for erogenous sensation. The denuded clitoris was always placed directly below the phallic shaft. Later manipulation of the neophallus allows for stimulation of the still-innervated clitoris. As described and analyzed in a previously published article on genital sensitivity, after one year, all patients had regained tactile sensitivity which is an absolute requirement for safe insertion of an erection prosthesis [30].

In a long-term follow-up study on postoperative sexual and physical health, more than 80% of our patients reported improvement in sexuality with the FTM transsexuals experiencing greater sexual satisfaction and greater ease in reaching orgasm: the full 100% of postoperative FTM transsexuals who were actively practicing sexual activity were able to reach an orgasm [28].

For FTM transsexuals seeking phalloplasty, the ability to void while standing is a high priority [21]. Unfortunately, the reported incidences of urological complications in all series of phalloplasties are extremely high, even up to 80% [39]. For this reason certain surgeons have even stopped reconstructing a complete neo-urethra [20,40]. In our series of radial forearm phalloplasties, the urological complication rate with 41% (127/316) of the patients presenting an early fistula and/or a stricture seems rather high. However, this rate is still low compared to other reports [8, 13, 22, 41], with no significant changes in recent years [42,43]. Most importantly, the majority of these early fistulas closed spontaneously. The unique feature of this series is the fact that *all* our patients were ultimately able to void through the newly reconstructed penis.

Despite our rate of urological complications, we choose not to perform prelamination of the urethra. In our series, most complications have occurred at the junction between the neo-urethra and the native urethra, not along the course of the flap-ure-

thra. We even believe that the previous surgery of the prelamination of the urethra could lead to increased problems at the anastomosis site. We have also been able to demonstrate that the effects on urinary tract function are minimal after phalloplasty combined with reconstruction of the fixed part of the urethra [30]. However, it is unknown how the new urethra – a 16 cm skin tube – will affect bladder function in the long term. Therefore, lifelong urological follow-up is mandatory for these patients.

Complications following phalloplasty included the general complications attendant to any surgical intervention: the few wound healing problems in the groin area mostly resolved with conservative measures. Despite interrupting hormonal therapy and routine subcutaneous heparin combined with elastic stockings, 3 patients developed a (minor) pulmonary embolism. A vaginectomy is a particularly difficult operation, which carries a high risk of post-operative complications, especially when combined with a simultaneous hysterectomy; however, no major bleedings or other complications were seen in this series of patients [31]. 2 early patients displayed symptoms of nerve compression in the lower leg but after reducing the length of the gynecological positioning to under 2h, this complication never occurred again.

Apart from a urinary fistula and/or stenosis, most complications of the radial forearm phalloplasty are related to the free tissue transfer. Baudet reported that microvascular transfer in penile reconstruction resulted in more complications than with other free flaps [44]. Still, the total flap failure in this series was very low (<1%, 2/316). On the other hand, the revision rate because of early vascular compromise was rather high (11.3% or 36/316). About 7.2% of the patients demonstrated a minor degree of partial flap necrosis. This was more often the case in smokers, in those who insisted on a large-sized penis requiring a larger flap, and also in patients having undergone anastomotic revision.

With *smoking* being a significant risk factor, under our current policy, we no longer operate on patients who fail to quit smoking one year prior to their surgery.

As already described in previously published articles of our group, the overall complication rate was higher in the beginning of this series compared to the later periods most probably due to a learning-curve effect in performing these operations [25,27,31,33].

The major drawback of the radial forearm flap has always been the unattractive donor site scar on the forearm (◉ Fig. 5). We conducted a long-term follow-up study [26] to assess the degree of functional loss and aesthetic impairment after harvesting such a large forearm flap. We had expected increased morbidity, but we found that our early and late complications did not differ from the rates reported in the literature for the smaller flaps as used in head and neck reconstruction [26]. No major or long-term problems (such as functional limitation, chronic pain or cold intolerance) were identified. Finally, with regard to the aesthetic outcome of the donor site, we found that the patients were very accepting of the donor site scar, viewing it as a worthwhile trade-off for the creation of a phallus [26].

In a radial forearm phalloplasty, the insertion of an erection prosthesis is required in order to engage in sexual intercourse. For this purpose we always used the hydraulic systems available for impotent men. An early follow-up study indicated that in about 1 in 4 patients, a re-intervention was required due to malpositioning, technical failure, or infection [35]. A recent long-term follow-up study showed an explantation rate of 44% in 130



Fig. 6 After implantation of an erection prosthesis: **a** deflated and **b** in erection.

patients. Still, more than 80% of the patients were able to have normal sexual intercourse with penetration [25]. In another study, we demonstrated that patients with an erection prosthesis were more able to attain their sexual expectations than those without such a prosthesis [28] (● **Fig. 6**). A major concern regarding erectile prostheses is long-term follow-up. These devices were developed for impotent (older) men who have a shorter life expectancy and who are sexually less active than the mostly younger FTM patients. Nonetheless, we prefer the combination of a radial forearm phalloplasty with an erection prosthesis to the use of composite flaps such as the osteocutaneous radial forearm flap. In our opinion, the long part of this flap is insufficient for sexual intercourse, while high donor site morbidity remains. On the other hand, the osteocutaneous fibula flap is better suited for intercourse, but patients can be bothered by the constant erectile state of the phallus. Moreover, osteocutaneous fibula flaps can demonstrate an aesthetically unpleasant pointed deformity of the glans of the penis, where the extra skin can glide around the end of the fibula bone.

Conclusion

In this large retrospective clinical study we have shown that the radial forearm phalloplasty is a very reliable technique for the construction, usually in 2 stages, of a normal looking penis always allowing the patient to void while standing and in most cases also to experience sexual satisfaction. The main disadvantages of this technique are the rather high number of initial fistulas, the scar on the forearm, the possible slight loss of volume and the potential long-term urological complications. In the absence of prospective randomized studies, it is not possible to actually 'prove' that the radial forearm flap indeed is the 'gold standard' in penile reconstruction [45]. When, however, comparing our results with the rest of the literature, the alternatives are rarely considered as a better option. Nevertheless, it is up to the individual surgeon and the individual patient to judge to what degree the radial forearm flap is the best that plastic surgery has to offer in penile reconstruction. Finally, from our experience, we strongly feel that a structured multi-disciplinary cooperation between the reconstructive-plastic surgeon and the urologist is an absolute requisite to obtain the best possible technical results.

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