

Penile Reconstruction: Is the Radial Forearm Flap Really the Standard Technique?

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Background: The ideal goals in penile reconstruction are well described, but the multitude of flaps used for phalloplasty only demonstrates that none of these techniques is considered ideal. Still, the radial forearm flap is the most frequently used flap and universally considered as the standard technique.

Methods: In this article, the authors describe the largest series to date of 287 radial forearm phalloplasties performed by the same surgical team. Many different outcome parameters have been described separately in previously published articles, but the main purpose of this review is to critically evaluate to what degree this supposed standard technique has been able to meet the ideal goals in penile reconstruction.

Results: Outcome parameters such as number of procedures, complications, aesthetic outcome, tactile and erogenous sensation, voiding, donor-site morbidity, scrotoplasty, and sexual intercourse are assessed.

Conclusions: In the absence of prospective randomized studies, it is not possible to prove whether the radial forearm flap truly is the standard technique in penile reconstruction. However, this large study demonstrates that the radial forearm phalloplasty is a very reliable technique for the creation, mostly in two stages, of a normal-appearing penis and scrotum, always allowing the patient to void while standing and in most cases also to experience sexual satisfaction. The relative disadvantages of this technique are the rather high number of initial fistulas, the residual scar on the forearm, and the potential long-term urologic complications. Despite the lack of actual data to support this statement, the authors feel strongly that a multidisciplinary approach with close cooperation between the reconstructive/plastic surgeon and the urologist is an absolute requisite for obtaining the best possible results. (*Plast. Reconstr. Surg.* 124: 510, 2009.)

The construction of a penis is a challenging operation and even more so in a female-to-male transsexual because of the additional need for vaginectomy, scrotoplasty, and reconstruction of the horizontal part of the urethra. The surgeon's ideal goals in performing a phalloplasty include 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.^{1,2} Moreover, it should provide a normal scrotum and be predictably reproducible without functional loss or disfigurement in the donor area. Although to date these ideal goals have not been met, it is

still unclear what can realistically be expected after a state-of-the-art phalloplasty.

The first penile reconstructions required complex, multistage procedures using tubed skin flaps or pedicled myocutaneous flaps.³⁻⁶ More recently, microsurgical techniques have allowed for free tissue transfer with nerve coaptation. The multitude of free flaps that have been described demonstrate that none of these is really ideal.^{1,7-17} Still, the radial forearm flap is by far the most frequently used flap and is universally considered as the standard technique in penile reconstruction.^{1,18-20}

In this article, we present the largest series to date of radial forearm phalloplasties. The main purpose was to evaluate to what extent this supposed standard technique is able to approximate

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the criteria of ideal penile reconstruction. In this clinical study, we specifically looked at the following outcome parameters after phallic reconstruction with a free radial forearm flap:

1. Can a complete penile reconstruction be performed in one operation?
2. Does this technique result in an aesthetically appearing penis?
3. How is the tactile and erogenous sensation postoperatively?
4. Can the patient void while standing with the reconstructed penis?
5. What is the overall morbidity of this surgical intervention?
6. What is the residual functional and aesthetic damage at the donor site of the arm?
7. What are the results for the construction of a scrotum?
8. Can the patient experience sexual satisfaction postoperatively?

PATIENTS AND METHODS

Between 1992 and 2007, 287 consecutive phalloplasties were performed using a radial forearm flap, for the most part (280 of 287) in female-to-male transsexuals (Table 1).

In the early years of this series (1992 to 1997; $n = 59$), we advocated a so-called all-in-one surgical intervention that included a subcutaneous mastectomy, a lower abdominal hysterectomy and ovariectomy, and a complete genitoperineal transformation, all performed during one surgical intervention. Later in this series (1997 to 2001; $n = 62$), we performed a subcutaneous mastectomy (only) as a first procedure, whereas from 2001 on ($n = 167$), the subcutaneous mastectomy was combined with a totally laparoscopic hysterectomy and ovariectomy.

For the genitoperineal transformation, two surgical teams operate simultaneously: the urologist performs a vaginectomy and reconstructs the fixed part of the urethra in combination with a scrotoplasty while the plastic surgeon dissects the radial forearm flap and constructs a tube-within-a-tube phallus.¹⁵ A glans is created with a small skin flap and a full-thickness skin graft (Fig. 1).

Table 1. Indications for Penile Reconstruction (n = 287)

	No. (%)
Female-to-male transsexualism	280 (97.6)
Penile aplasia	4 (1.4)
Posttraumatic	2 (0.7)
After oncologic resection	1 (0.35)

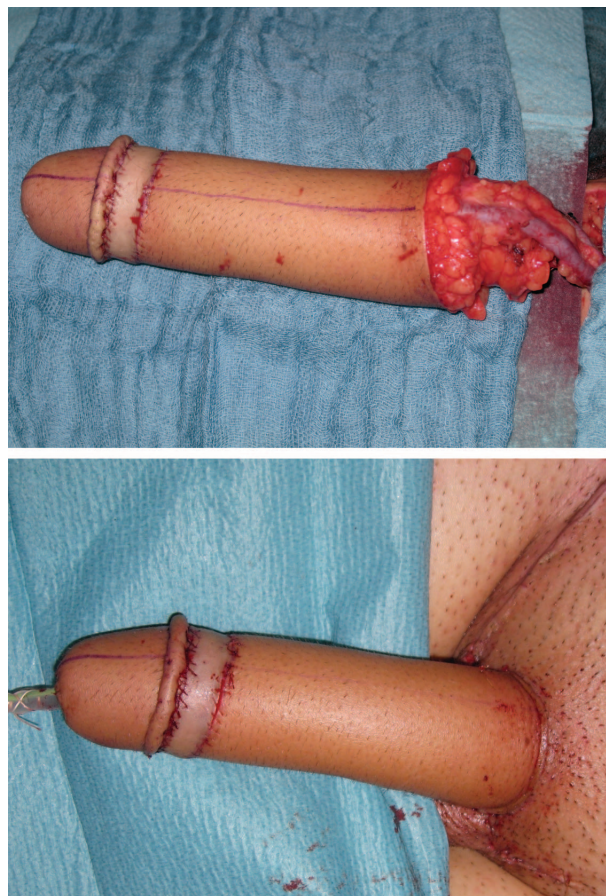


Fig. 1. Perioperative view of penile reconstruction with a radial forearm flap, with flap still attached to the arm (above) and at the end of the operation (below).

Once the receptor vessels are dissected in the groin, the free flap is transferred to the pubic area: the radial artery is 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 is connected to the ilioinguinal nerve and the other is connected to one of the dorsal clitoral nerves. The clitoris is deepithelialized and buried underneath the penis, just above the pubic bone symphysis.

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.

All patients receive a suprapubic urinary diversion postoperatively. The transurethral catheter is usually removed after 8 days and voiding starts after 12 days. Tattooing of the glans can be performed after a 2- to 3-month period, before sensation returns to the penis (Fig. 2).

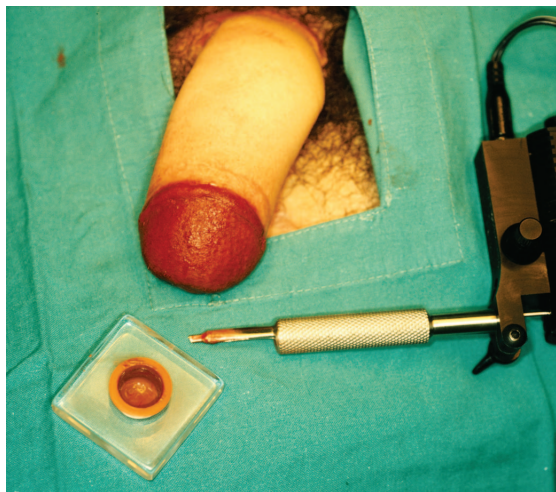


Fig. 2. Photograph showing tattooing of the glans of the penis.

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 urologic check-up in all these patients allowed for systematic long-term follow-up by all team members (i.e., psychiatrist, gynecologist, endocrinologist, and plastic surgeon).

RESULTS

The average hospital stay was 2½ weeks (range, 16 to 41 days). The complications, for the whole period (1992 to 2007) and broken down by the three different time periods (1992 to 1997, 1997 to 2001, and 2001 to 2007), are listed in Table 2:

34 of 287 patients (12 percent) required early anastomotic revision because of an arterial thrombosis ($n = 5$), a venous thrombosis only ($n = 9$), or a combination of both ($n = 20$). In all revisions, an arteriovenous fistula was constructed at the distal end of the penis to improve venous outflow.²¹

There was complete flap loss in two patients (both older and heavy smokers). Some superficial skin slough occurred in 17 of 287 patients (6 percent), and partial flap loss with some full-thickness skin necrosis in the distal part of the flap (<10 percent) was seen in 21 of 287 patients (7.5 percent). In the former group, all wounds healed by secondary intention, whereas in the latter group, an additional surgical procedure (débridement, secondary closure, or skin grafting) was required in 13 of the 21 patients (62 percent). Three patients developed a (minor) pulmonary embolism. There was a partial nontake of the skin graft at the arm in 11 patients, with only eight of them requiring a small re-grafting procedure.

Minor wound-healing problems in the groin or lower abdominal area were observed in 32 patients, and in most of the cases (29 of 32), these healed with conservative means only. Two (early) patients demonstrated symptoms of nerve compression in the lower leg caused by prolonged gynecologic positioning.

Urologic complications were seen in 41 percent of the patients (119 of 287), with a fistula in 72, a stricture in 21, and a combination of both in 26. The majority of the fistulas (51 of 74) closed spontaneously, and many strictures (especially at the meatus) could be managed with dilatation

Table 2. Complications

	Overall (%)	1992–1997 (%)	1997–2001 (%)	2001–2007 (%)
No.	287	59	62	167
Flap-related				
Anastomotic revision	34 (12)	8 (13.6)	7 (11.2)	19 (11.3)
Complete flap loss	2 (0.7)	1 (1.7)	1 (1.6)	0
Marginal partial necrosis (13 additional operations)	21 (7.3)	6 (10)	5 (8)	10 (6)
Urologic				
Early fistula (closing spontaneously)	51 (17.7)	12 (20)	12 (19.4)	27 (16.1)
Stricture treated conservatively	21 (7.3)	5 (8.4)	5 (8)	11 (6.5)
Fistula/stricture requiring urethroplasty (97 additional operations)	52 (18.1)	12 (20)	12 (19.4)	28 (16.7)
Various				
Minor pulmonary embolism	3 (1)	1 (1.7)	2 (3.2)	0
Re-grafting of defect on arm	2 (0.7)	1 (1.7)	1 (1.6)	0
Nerve compression (early cases)	2 (0.7)	2 (3.3)	0	0
Delayed wound healing in groin area (four additional operations)	32 (11.1)	9 (15.2)	7 (11.2)	16 (9.6)
Erectile prosthesis (130 prostheses)				
No.	130	21	32	77
Revision surgery	58 (44.6)	13 (62)	16 (50)	29 (37.6)
Incapacity to perform sexual intercourse	26 (20)	6 (28.5)	7 (22.6)	13 (17)

only. In the other patients ($n = 49$), a secondary or even tertiary urethroplasty procedure was necessary. In 52 patients, a total of 97 procedures were needed to obtain an unobstructed urethra.

In 130 patients, an erectile device was implanted. Different types of prostheses have been used. In nine patients, a Dynaflex (American Medical Systems, Inc., Minnetonka, Minn.) was implanted; in 68 patients, an AMS CX was implanted; in 47 patients, an Ambicor (American Medical Systems) device was implanted; and in six patients, a Mentor prosthesis (Coloplast, Humlebaek, Denmark) was implanted. With a mean follow-up of 22.2 months, the original implant was in place in 72 of the 130 implanted patients (55.4 percent) or 72 of 287 patients (25 percent) in the entire group. Fifty-eight patients (44.6 percent) needed to undergo removal or revision surgery because of infection or erosion [18 patients (13.8 percent)] or dysfunction or leakage [40 patients (30.8 percent)]. The Ambicor group (American Medical Systems) had the best results.²²

Despite this high explantation rate, the implantation of an erectile device is still the only option that allows a female-to-male transsexual to have satisfactory intercourse. An evaluation of the aesthetic aspect of the penis was judged almost consistently as better by the patient compared with the surgeon or an independent observer.²³

For a more elaborate description of the outcome parameters, we refer to the previously published articles on urologic aspects,²⁴ on sexual and physical health,²⁵ on long-term psychological follow-up,²⁶ on genital sensitivity,²⁷ on two-stage versus one-stage surgery,²⁸ on radial forearm phalloplasty itself,¹⁵ on erectile prosthesis^{22,29} on donor-site morbidity,²³ and on scrotoplasty.³⁰ In these articles, it was shown that the rating of the surgical result after a phalloplasty procedure in a transsexual individual is not that much dependent on the occurrence of complications or on the final aesthetic result but extend more to different, other postoperative aspects related to the change in the patient's social role and long-term improvement in quality of life.^{22,23,25-27}

DISCUSSION

The ideal goals in penile reconstruction have been well described^{1,2} but the plethora of phalloplasty techniques implies that none 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.^{1,8,13,16,17,31,32} The radial fore-

arm flap is used in up to 90 percent of all phalloplasties that have been reported on and is universally considered as the best flap for penile reconstruction.^{7,15,18,20,33}

In this article, we describe the largest series to date of 287 radial forearm phalloplasties performed by the same team of surgeons. Many different outcome parameters have been described separately in previously published articles, but the purpose of this overview article is to evaluate to what degree this supposed standard technique (in our hands) has been able to meet the ideal goals in phallic reconstruction.

One-Stage Procedure

We agree with Hage and de Graaf,² who indicated that a complete penile reconstruction with erection prosthesis never can be performed in a single operation. Early in this series, to reduce the number of operations, we performed an all-in-one procedure that included a subcutaneous mastectomy and a complete genitoperineal transformation. Later in our series, we performed the subcutaneous mastectomy first and more recently in combination with a totally laparoscopic hysterectomy and ovariectomy.

The reason for changing our protocol was that lengthy operations (>8 hours) resulted in considerable blood loss and increased operative risk.²⁸ Moreover, an aesthetic subcutaneous mastectomy is not an easy operation and should not be performed "quickly" before the major phalloplasty operation.³⁴

Aesthetic Phallus

To construct an aesthetic penis, it is essential to use a technique that can be replicated 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 glansplasty is performed, often in combination with tattooing of the glans at a later stage (Fig. 3).

The final cosmetic 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 cosmetic barometer. For a more extensive description of patient and surgeon satisfaction, we refer to our previously published articles.^{22,23,25-27} In most cases, the outcome was seen as more aesthetic by the patient compared with the surgeon or an independent observer.²³ The potential drawbacks of

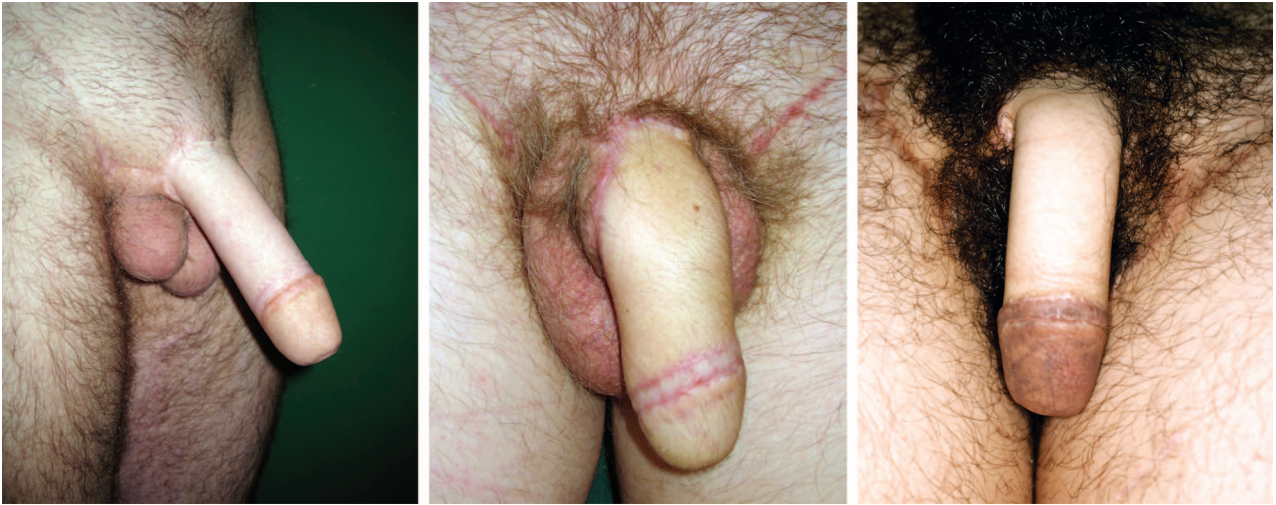


Fig. 3. Photographs showing the long-term aspect of radial forearm phalloplasty.

the radial forearm flap are the need for a rigid prosthesis and possibly some volume loss over time.

Tactile and Erogenous Sensation

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.³⁵ We always connect one antebrachial nerve to the ilioinguinal nerve for protective sensation and the other forearm nerve with one dorsal clitoral nerve. 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 1 year, all patients had regained tactile sensitivity, which is an absolute requirement for safe insertion of an erection prosthesis.²⁷ In a long-term follow-up study on postoperative sexual and physical health, more than 80 percent of our patients reported improvement in sexuality, with the female-to-male transsexuals experiencing greater sexual satisfaction and greater ease in reaching orgasm: 100 percent of postoperative female-to-male transsexuals who were actively practicing sexual activity were able to reach an orgasm.²⁵

Voiding while Standing

For female-to-male transsexuals seeking phalloplasty, the ability to void while standing is a high priority.¹⁸ Unfortunately, the reported incidences of urologic complications in all series of phalloplasties are extremely high, even up to 80 percent.³⁶ For this

reason, certain surgeons have even stopped reconstructing a complete neourethra.^{17,37}

In our series of radial forearm phalloplasties, the urologic complication rate with 41 percent of the patients (119 of 287) presenting an early fistula and/or a stricture seems rather high. However, it is still low compared with other reports^{1,19,38,39} and, 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. 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.²⁷ However, it is unknown how the new urethra—a 16-cm skin tube—will affect bladder function in the long term. Therefore, life-long urologic follow-up is mandatory for these patients.

Minimal Morbidity

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, three patients developed a (minor) pulmonary embolism.

A vaginectomy is a particularly difficult operation, which carries a high risk of postoperative complications, especially when combined with a simultaneous hysterectomy; however, no major

bleeding or other complications were seen in this series of patients.²⁸ Two early patients displayed symptoms of nerve compression in the lower leg; however, after we reduced the length of the gynecologic positioning to under 2 hours, this complication never occurred again.

Apart from a urinary fistula and/or stenosis (see earlier under Voiding while Standing), 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.⁴⁰ Still, the total flap failure in this series was very low [two of 287 (<1 percent)]. In contrast, the revision rate attributable to early vascular compromise was rather high [34 of 287 (12 percent)]. Approximately 7.3 percent 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 1 year before surgery.

Comparing the overall complication rates with the numbers broken down by each of the three time periods (Table 2) clearly demonstrates that the complication rate was consistently higher in the beginning of this series compared with the later periods. This is most probably because of a learning-curve effect in performing these operations as described in previously published articles of our group.^{22,24,28,30}

No Functional Loss and Minimal Scarring in the Donor Area

The major drawback of the radial forearm flap has always been the unattractive donor-site scar on the forearm (Fig. 4).

We conducted a long-term follow-up study²³ 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.²³ 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 tradeoff for the creation of a phallus.²³

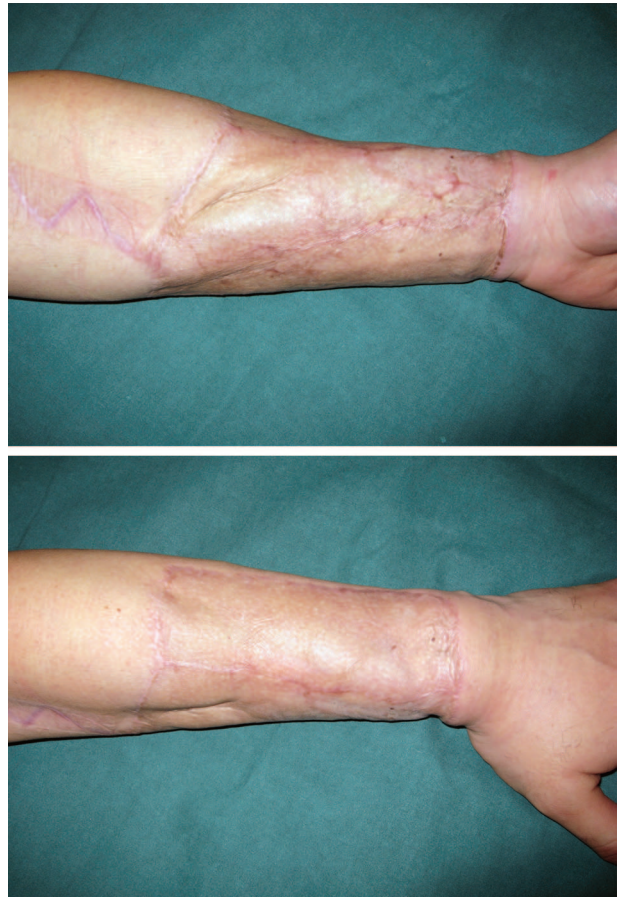


Fig. 4. Photographs showing the long-term aspect of the donor site on the forearm.

Normal Scrotum

The goal of creating natural-appearing genitals also applies to the scrotum. As the labia majora are the embryologic counterpart of the scrotum, many scrotoplasty techniques have used this hair-bearing skin. Previous approaches left the labia in situ, with midline closure and prosthetic implant filling, or brought the scrotum in front of the legs using a V-Y plasty. These techniques were aesthetically unappealing and reminiscent of the female genitalia.

For the past 5 years, we have used a novel scrotoplasty that combines a V-Y plasty with a 90-degree turning of the labial flaps, resulting in an anterior transposition of labial skin (Fig. 5). The excellent aesthetic outcome of this male-appearing scrotum, the functional advantage of fewer urologic complications, and the easier implantation of testicular prostheses make this the technique of choice.³⁰

Sexual Intercourse

In a radial forearm phalloplasty, the insertion of an erection prosthesis is required to en-



Fig. 5. Photographs demonstrating a novel scrotoplasty technique before (*left*) and after (*right*) implantation of erection and testicular prostheses.

gage in sexual intercourse. For this purpose, we always used the hydraulic systems available for impotent men.

An early follow-up study indicated that in approximately one in four patients, a reintervention was required because of malpositioning, technical failure, or infection.²⁹ A recent long-term follow-up study showed an explantation rate of 44 percent in 130 patients. Still, more than 80 percent of the patients were able to have normal sexual intercourse

with penetration.²² In another study, we demonstrated that patients with an erection prosthesis were more able to attain their sexual expectations than those without a prosthesis²⁵ (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 female-to-male transsexual patients.



Fig. 6. Photographs of a patient after implantation of an erection prosthesis, with the prosthesis deflated (*left*) and in erection (*right*).

CONCLUSIONS

In the absence of prospective randomized studies, from which transsexual patients are virtually excluded, it is not possible to actually “prove” whether the radial forearm flap indeed is the standard technique in penile reconstruction.⁴¹ However, in this large study, we have shown that the radial forearm phalloplasty is a very reliable technique for the construction, usually in two stages, of a normal-appearing 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, and the potential long-term urologic complications.

Although when comparing our results with the rest of the literature one might think that for the majority of patients who need a phalloplasty, the alternatives are rarely considered as a better option, it is still 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. Despite the lack of actual data to support this statement, we strongly feel that a multidisciplinary approach with close cooperation between the reconstructive plastic surgeon and the urologist is an absolute requisite for consistently obtaining the best possible results.

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Instructions for Authors: *Update*

Registering Clinical Trials

Beginning in July of 2007, *PRS* has required all articles reporting results of clinical trials to be registered in a public trials registry that is in conformity with the International Committee of Medical Journal Editors (ICMJE). All clinical trials, regardless of when they were completed, and secondary analyses of original clinical trials must be registered before submission of a manuscript based on the trial. Phase I trials designed to study pharmacokinetics or major toxicity are exempt.

Manuscripts reporting on clinical trials (as defined above) should indicate that the trial is registered and include the registry information on a separate page, immediately following the authors' financial disclosure information. Required registry information includes trial registry name, registration identification number, and the URL for the registry.

Trials should be registered in one of the following trial registries:

- <http://www.clinicaltrials.gov/> (Clinical Trials)
- <http://actr.org.au> (Australian Clinical Trials Registry)
- <http://isrctn.org> (ISRCTN Register)
- <http://www.trialregister.nl/trialreg/index.asp> (Netherlands Trial Register)
- <http://www.umin.ac.jp/ctr> (UMIN Clinical Trials Registry)

More information on registering clinical trials can be found in the following article: Rohrich, R. J., and Longaker, M. T. Registering clinical trials in *Plastic and Reconstructive Surgery*. *Plast. Reconstr. Surg.* 119: 1097, 2007.