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A NEW BIAXIAL EPILATED SCROTAL FLAP FOR RECONSTRUCTIVE URETHRAL SURGERY

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ABSTRACT

Purpose: We describe a new type of perineum based scrotal flap with biaxial vascularization supplied by both superficial perineal arteries. Flap length of up to 20 cm. may be attained for urethral reconstruction.

Materials and Methods: A total of 37 men with complex urethral stenosis of different etiologies underwent surgery using 1 of 3 urethroplasty techniques based on this new flap. The whole anterior urethra, including pendulous and bulbar segments, was reconstructed with a scrotal patch in 10 patients. A scrotal tubular flap was used as a substitute for the bulbar urethra in 7 patients and for the membranous portion in 4. Bulbar urethroplasty with a scrotal island patch was performed in 16 patients.

Results: Of the patients 86% achieved normal voiding after 1-stage urethroplasty. Mean followup was 39.5 months.

Conclusions: The excellent axial vascularization of this new flap permits successful resolution of the most complex urethral stenoses regardless of extension, location and etiology.

KEY WORDS: urethra, scrotum, surgical flaps, urethral stricture

Pediculated skin flaps have always offered the best long-term results after surgery for complex urethral stenosis, relegating any type of free graft to second place. The reason is obvious, since vascularization of the skin forming the neourethra is kept intact at all times and constant trophism is ensured. Skin flaps are usually used empirically in reconstructive urethral surgery and little is known scientifically of their anatomical bases and different classifications. Six basic characteristics should be considered when designing a flap: 1) circulation, 2) constituents, 3) construction, 4) conformation, 5) contiguity and 6) conditioning.[1]

With respect to vascularization, randomized and axial skin flaps have classically been distinguished. No arterial vessel of considerable caliber is considered in the randomized circulation flap and its nutrition depends on small dermo-epidermal or reticular plexus vessels. In contrast, an axial circulation flap is constructed over a vascular pedicle, which runs along the longitudinal axis of the flap and supplies a clearly delimited anatomical area.[2] More recently, Kunert proposed a practical classification system for flaps correlating the anatomical surgical variables, disposition of vascular pattern and how they can be moved.[3] This system is best adapted to the requirements of reconstructive urethral surgery, since the main key to ensuring the viability of all flaps is preservation of continuity among the 3 basic circulation levels (fig. 1).[3]

For surgical purposes the urethra can be divided into the anterior portion composed of the pendulous and bulbar urethra, and the posterior portion formed by the membranous and prostatic urethra. To our knowledge there has been no discussion on the use of preputial and penile skin flaps for reconstruction of the pendulous urethra in children and adults.[4,5] However, unanimity of criteria is lacking regarding the most ideal type of flap for resolving stenoses affecting the bulbar and membranous portions, and those that compromise the whole anterior urethra (panurethral disease).[6]

Due to contiguity with bulbar and membranous segments scrotal and perineal skin has been widely used in different urethroplasty techniques. Initially these flaps were of reticular or randomized vascularization and, therefore, they involved major technical restrictions that made it necessary to perform the procedures in 2 stages.[7] In 1967 Gil-Vernet first described the perineal based scrotal flap with a reticular pattern designed in an inverted U over the posterior face of the scrotum.[8] Subsequently this flap was erroneously reported as an original technique by Blandy et al, who later modified it in the form of an island flap, permitting urethroplasty to be performed in 1 stage.[9,10] Based on our vast experience with the perineal scrotal flap and better anatomical understanding of the arteries supplying the skin, we present a new scrotal flap with double axial vascularization that broadens the indications and improves the results of reconstructive urethral surgery.

MATERIALS AND METHODS

All anatomical terms used correspond to the international anatomical nomenclature.[11] We defined the anatomical bases for obtaining the biaxial scrotal flap.

Circulation. The cutaneous branches of the superficial perineal artery (A. perinealis) pass through the superficial perineal aponeurosis (fascia perinei superficialis) and ascend inside the subcutaneous cell tissue of the perineum, running into the so-called scrotal space, delimited by the external spermatic fascia and tunica dartos. These posterior scrotal arteries (rami escrotales posteriores) ascend in parallel 2 or 3 per side, separated from each other by 2 cm. (fig. 2, *A*). External or superficial branches leave the trunk, and anastomose with each other and with branches of the anterior scrotal arteries (branches of the inferior external pudendal artery) (fig. 2. *B*). There also exist 2 or 3 internal or deep arterial branches that lead toward the septum, where they anastomose with the contralateral branches and branches from the anterior scrotal arteries. These arterial branches that course along each side of the scrotal raphe and scrotal septum provide profuse bilateral axial vascularization to the flap (fig. 2, *C*).[12]

Constituents. Scrotal skin, dartos, external spermatic fascia, cremasteric fibers and fascia, internal spermatic fascia

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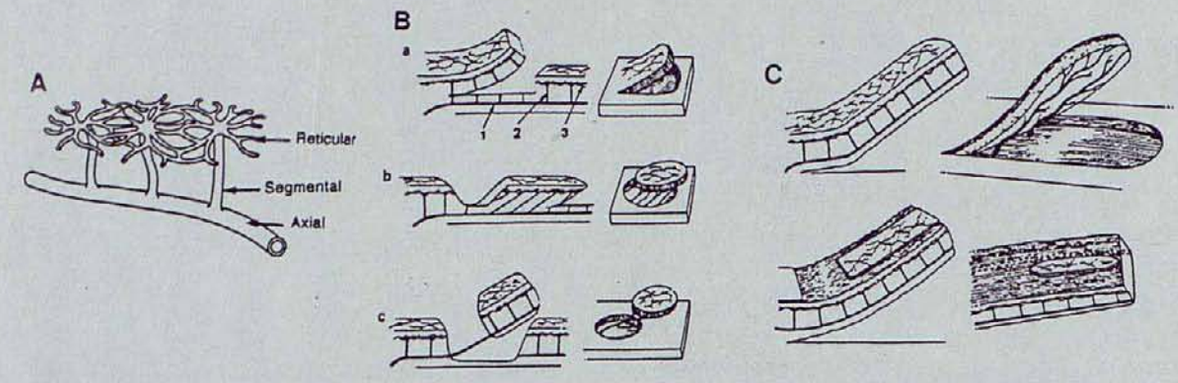

FIG. 1. *A*, 3 elemental vascular patterns that irrigate skin.[3] *B*, 3 flap types according to vascularization and mobility. *a*, limited mobility reticular circulation flap with axial (*1*), segmental (*2*) and reticular (*3*) vessels. *b*, scant mobility segmental circulation flap. *c*, maximum mobility axial circulation flap. *C*, pediculated flap proposed for reconstructive urethral surgery maintains continuity among axial, segmental and reticular circulation.

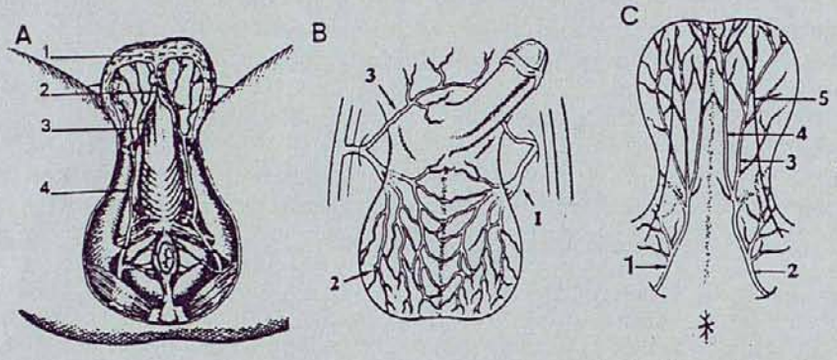

FIG. 2. Scrotal arterial network.[12] *A*, frontal section of perineoscrotal area with scrotal wall (*1*), scrotal septum (*2*), posterior medial scrotal branch (*3*) and superficial perineal artery (*4*). *B*, anterior scrotal face with inferior external pudendal artery (*1*), rami scrotales anteriores (*2*) and superior external pudendal artery (*3*). *C*, posterior scrotal face with superficial perineal arteries (*1* and *2*), lateral (*3*) and medial (*4*) rami scrotales posteriores, and skin incision (*5*) for obtaining biaxial flap.

and the scrotal septum are included in the flap but the tunica vaginalis is excluded. Thus, vascular anastomoses between the cremasteric (deep) and scrotal (superficial) circulation are also included in the flap (fig. 3).

Conditioning. The skin of the scrotal flap that forms the neourethra is always epilated by selective thermocoagulation of the dermal papilla 3 months before surgery.[13] When scrotal skin is scarce and urethral stenosis is extensive (panurethral disease), extra skin is obtained by placing a tissue expander inguinally in each hemiscrotum 1 or 2 months earlier. The expander is withdrawn at urethroplasty.

SURGICAL TECHNIQUE

Construction. A rectangular 5 cm. flap is drawn on the stretched skin of the posterior scrotal face, centered over the mid raphe. Length varies and the flap may be prolonged on the anterior scrotal face depending on the urethral extension to be reconstructed. It is important to maintain the scrotal raphe as the longitudinal axis of the flap, since the medial scrotal arteries ascending on each side are always incorporated. At the perineal scrotal junction the incision lines separate toward the ischiatic tuberosities but never reach them (fig. 2, *C*). After the scrotal wall is sectioned along the lines marked for flap design, both testes are exposed with the vaginal covering, and the scrotal septum, which must be included in the flap, is removed. This maneuver is initiated in the penoscrotal angle, where the septum divides into 2 sheets that surround the penis root and fuse with the fascia penis superficialis and suspensory penile ligament (fig. 4, *A*). Removal of the scrotal septum is completed following the midline of the urethral spongy body and bulbospongiosus muscle as far as the perineal scrotal junction, where the upper edge

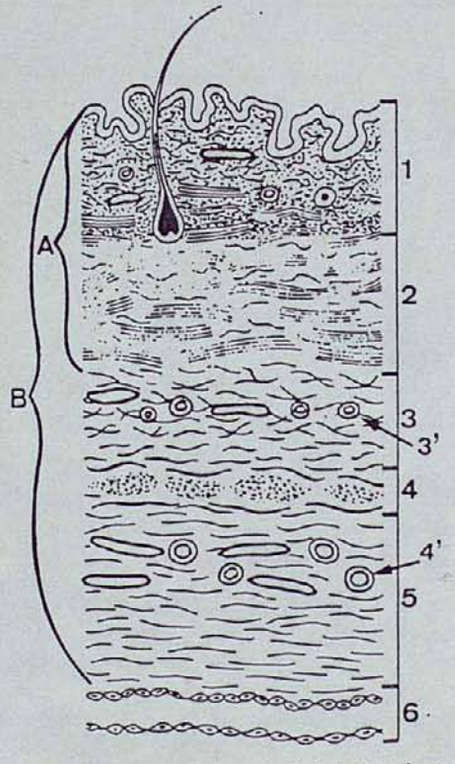

FIG. 3. Section of scrotum with scrotal skin (*1*), dartos (*2*), external spermatic fascia (*3*), rami scrotales (*3'*), cremasteric fascia and muscle fibers (*4*), cremasteric vessels (*4'*), internal spermatic fascia (*5*), tunica vaginalis (*6*), and components of conventional perineoscrotal (*A*) and new biaxial epilated scrotal flap (*B*).

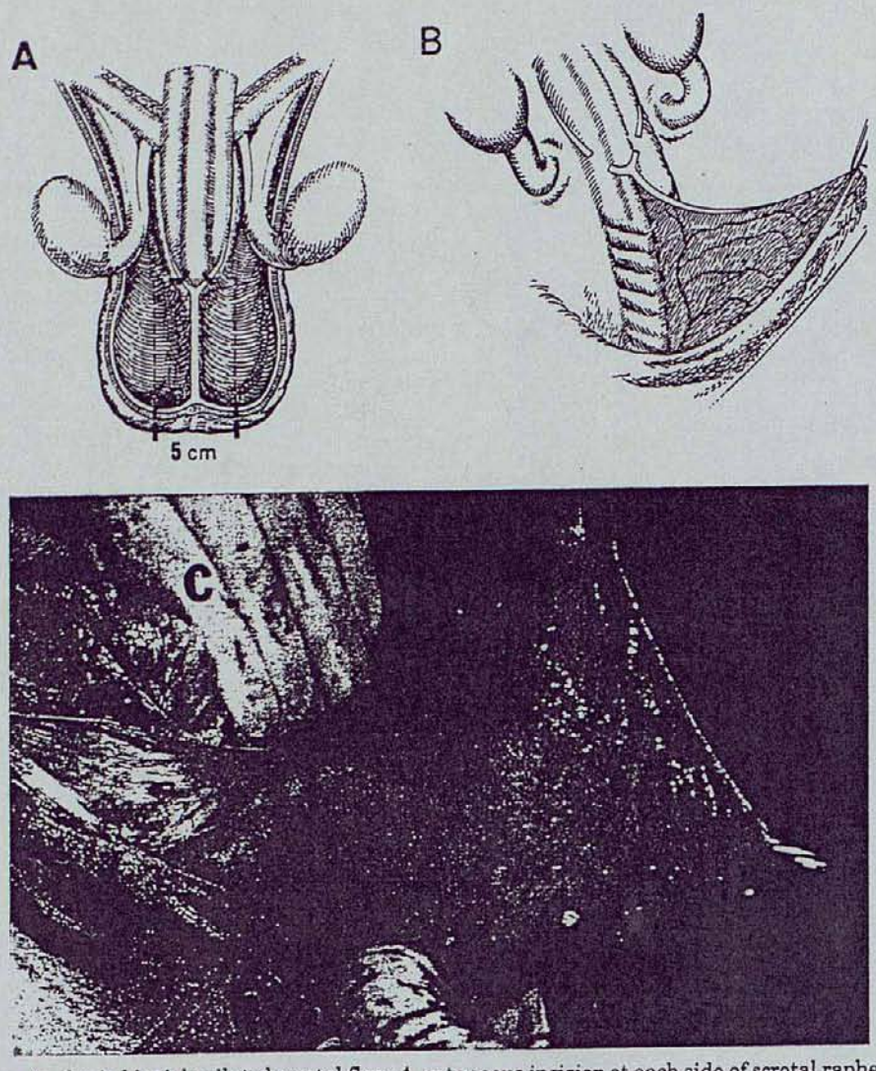

FIG. 4. Surgical incisions to obtain biaxial epilated scrotal flap. *A*, cutaneous incision at each side of scrotal raphe incorporates septum and all testicular coverings except vaginalis. *B*, detachment of scrotal septum. *C*, transillumination of detached scrotal septum reveals rich vascularization.

of the superficial perineal fascia is palpated (fig. 4, *B* and *C*). This fascia is a highly important point of reference, since with the fascia diaphragmatis urogenitalis inferior it delimits the spatium perinei superficiale, which is crossed laterally by the perineal arteries in their ascent toward the posterior scrotal face. Therefore, to avoid damaging the perineal vessels and their cutaneous branches, surgical section must avoid the superficial perineal fascia and never extend toward the ischiatic tuberosities (fig. 5). The newly formed flap has a wide trapezoidal perineal base and a 5 cm. wide rectangular shape along the scrotal raphe. This disposition permits perineal arterial pedicles and their medial cutaneous branches to be included (fig. 6).

Contiguity. The longitudinal axis of the flap is centered on the midline and on a coronal plane near the bulbar urethra. This position permits reconstruction of a urethral lesion, which may extend from the bulbomembranous portion to the urethral meatus, without any torsion or stretching of its double vascular pedicle.

Conformation. Before raising the flap a central cutaneous strip is drawn on it, wide and long enough to reconstruct the damaged urethra, and de-epithelialization is performed around it (fig. 7, *A* and *B*). De-epithelialization ensures maximal reticular vascularization of the skin flap and preserves the continuity of the 3 circulation levels. Undermining the skin destroys the integrity of reticular and segmental vascular anastomoses and, therefore, it must always be avoided.[14] It is advisable not to complete de-epithelialization in the central base of the patch until urethroplasty is almost complete to be able to dispose of excess length, if required. Thus, a longitudinal central skin patch is obtained that rests on a wide biaxial scrotal flap and permits 3 types of urethroplasty, including tube substitution, island patch and total urethroplasty.

Tubular Urethroplasty: The central 3 cm. skin strip is tubularized on a 20F catheter with 5-zero absorbable continuous polyglycolic acid sutures and skin eversion is avoided. A second plane may be made by suturing above the outer edges of the flap with interrupted polyglycolic acid sutures, and the tube is formed by a thick musculocutaneous wall (fig. 7, *C* and *D*). Following segmental urethrectomy the tubularized flap is interposed by rotating it 135 degrees on its perineal scrotal base, which inverts its 2 ends (fig. 8, *A*). Proximal and distal anastomoses with the healthy urethra are performed with 5-zero absorbable interrupted sutures (fig. 8, *B*). In posttraumatic stenosis of the bulbomembranous urethra the tubular flap is interposed between the prostatic apex and healthy bulbar urethra by a perineal or combined suprapubic approach in the most complex cases without the need for mobilizing the prostate or pubectomy (figs. 9 and 10).

Island Patch Urethroplasty: A 1 cm. skin island that will be used for enlarging plasty is drawn in the center and midline of the biaxial flap. The whole diseased urethra is incised on the ventral face until more than 1 cm. of healthy tissue is

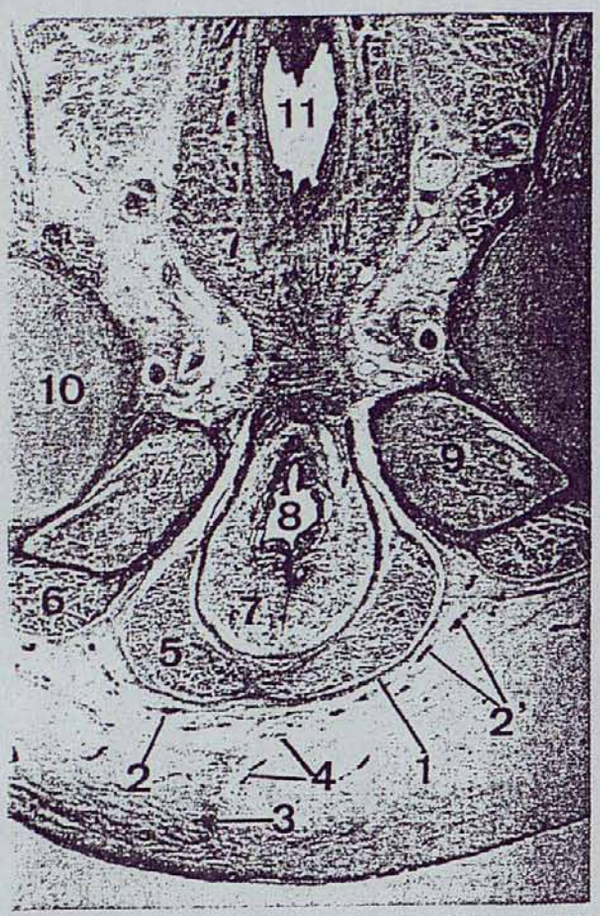

FIG. 5. Transverse section of perineal region of 16-week 132 mm. embryo shows superficial perineal fascia (*1*), cutaneous branches (*2* and *2'*) of superficial perineal vessels, scrotal septum (*3*) and vessels (*4*), bulbospongiosus muscle (*5*), ischiocavernous muscle (*6*), spongiosum (*7*), bulbar urethra (*8*), cavernous body (*9*), ischiopubic bone (*10*) and bladder (*11*).

attained at both ends, and the edges are sutured with the island patch using 5-zero absorbable interrupted sutures (fig. 11). Stenosis that affects the bulbar urethra, particularly those of the bulbomembranous portion, are the main indication for this technical variant (fig. 12).

Total Urethroplasty: The whole anterior urethra from the bulbomembranous portion to the meatus is reconstructed with a 20 × 2.5 cm. central skin patch drawn on the biaxial scrotal flap, which is extended on the anterior and posterior scrotal faces (fig. 13). After the flap has been raised its central portion is sutured to the edges of the fully opened urethra as far as the urethral meatus, and the cutaneous edges of the penis are then sutured to those of the scrotum (fig. 14). After a minimum of 6 months the penis is freed from the scrotum, preserving the deep vascularization that supplies the biaxial flap (fig. 15). This technique is indicated for resolution of panurethral disease (fig. 16).

Patients and followup. From April 1989 to March 1996 surgery was performed in 37 patients 16 to 77 years old (mean age 51) with complex urethral stenosis ranging from 2 to 20 cm. long and of diverse etiology (infection in 13, trauma in 13, iatrogenic injury in 10 and unknown in 1). Prior intervention had been attempted in 18 of 37 patients, including endoscopic urethrotomy in 12, end-to-end anastomosis in 2, and urethroplasty with lyophilized dura mater, Blandy type of urethroplasty, 2-stage urethroplasty and urethral stenting in 1 each. A total of 18 patients had been treated with periodic urethral dilation. The table lists stenosis location, length and surgical technique.

The urethral catheter was withdrawn on day 7 postoperatively and the suprapubic tube was removed after 21 days with simultaneous voiding cystourethrography followup. All patients were monitored during the first year with uroflowmetry every 3 months, and antegrade and voiding urethrography and urethroscopy at 3 and 12 months. Posterior followup included uroflowmetry at 6-month intervals, and annual radiological and endoscopic examinations.

Number and types of urethroplasties performed at different sites for urethral stricture

Technique	No. Pts.	Length (cm.)	Site		
			Bulbar	Membranous	Pendulous + Bulbar
Tubular	11	5–9	7	4	
Patch	16	2–8	16		
Total	10	14–20			10

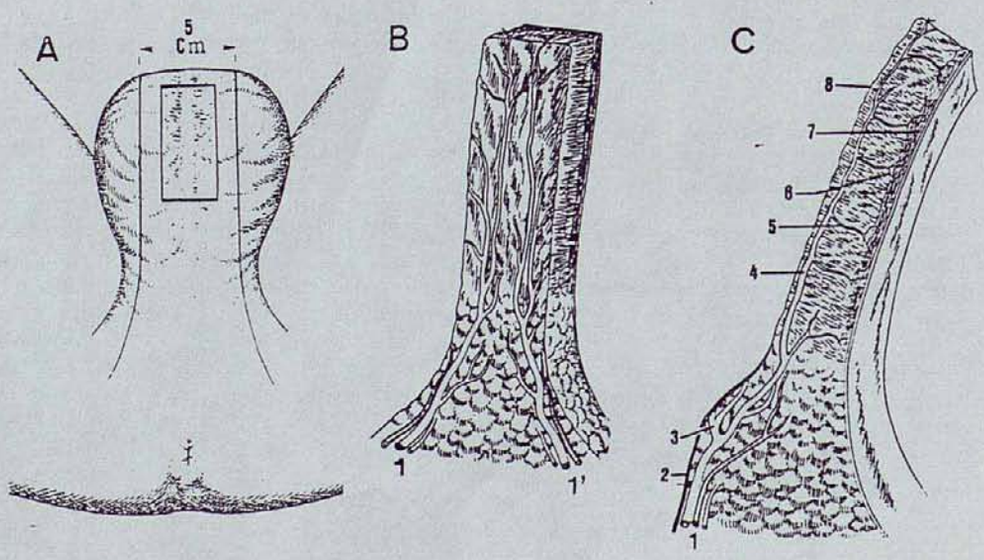

FIG. 6. New biaxial epilated scrotal flap. *A*, flap design on posterior scrotal face and profile of central skin patch used to reconstruct urethra. *B*, internal face of flap with right (*1*) and left (*1'*) perineal vascular nervous pedicle. *C*, lateral view of flap with perineal pedicle (*1*), superficial perineal fascia (*2*), arterial branches of septum (*3*), axial rami scrotal posterior vessel (*4*), segmental branch (*5*), dermo-epidermal reticular plexus (*6*), epilated skin and dartos (*7*), and internal spermatic fascia and scrotal septum (*8*).

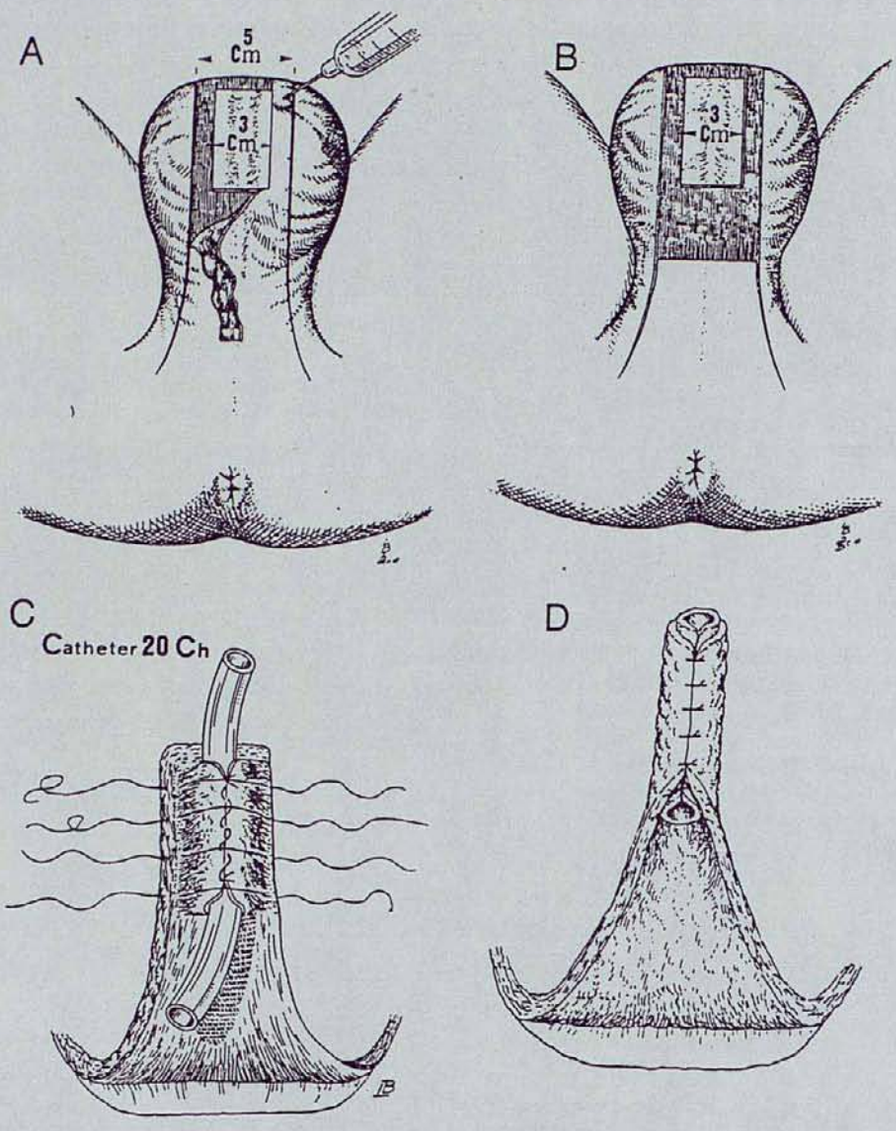

FIG. 7. Tubular urethroplasty flap configuration. *A*, in situ de-epithelialization is facilitated by intradermal injection of saline serum and stretched scrotal sac. *B*, central skin patch is placed on partially de-epithelialized biaxial scrotal flap. *C* and *D*, dual plane tubularization of patch over 20Ch catheter after raising flap.

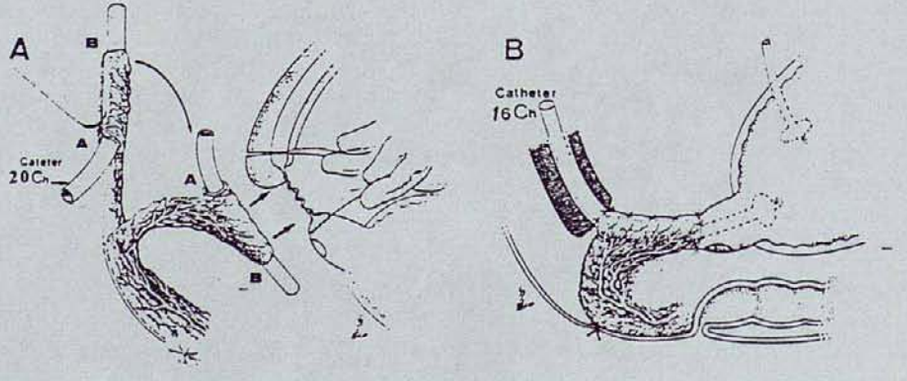

FIG. 8. Tubular urethroplasty bulbous and membranous segmental substitution. *A*, segmental urethrectomy and approach of flap swinging on perineal base. *B*, interposition and anastomosis of tubular flap.

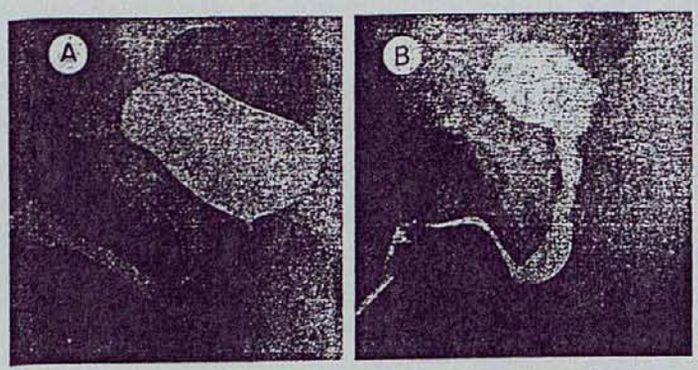

FIG. 9. Tubular urethroplasty in posttraumatic stenosis. *A*, preoperative retrograde urethrogram and antegrade cystogram. *B*, postoperative voiding cystourethrogram.

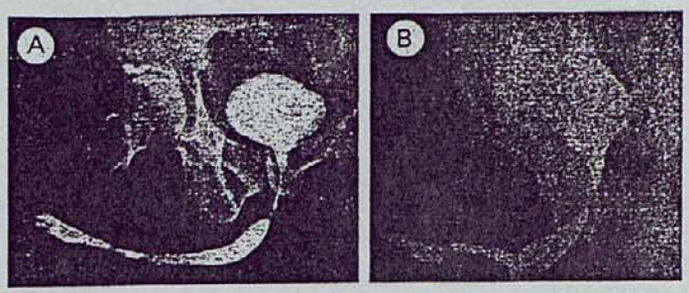

FIG. 10. Tubular urethroplasty for post-transurethral prostate resection stenosis treated unsuccessfully with urethral stent. *A*, preoperative retrograde cystourethrogram. *B*, postoperative voiding cystourethrogram. Simultaneous Yaxley urethroplasty was performed for pendulous urethral stricture.

RESULTS

A successful result was defined as the absence of clinical and radiographic evidence of stricture and maximum urinary flow more than 15 ml. per second. There were good results in 86% of the cases at a mean followup of 39.5 months (range 4 to 87). No fistulas or complications due to occasional isolated hairs in the neourethra were observed. Of 11 patients tubular urethroplasty failed in 2 with post-infection stenosis. Stricture recurrence due to urethral disease progression necessitated definitive perineal urethrostomy in 1 case and 2-stage urethroplasty in 1, which was successful. Island

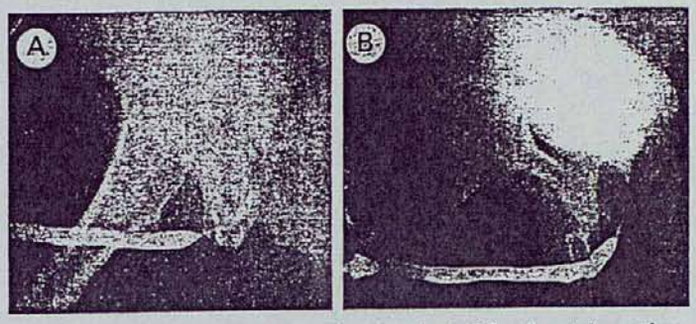

FIG. 12. Retrograde cystourethrography in island patch urethroplasty for stenosis after transurethral prostate resection. *A*, preoperative. *B*, postoperative.

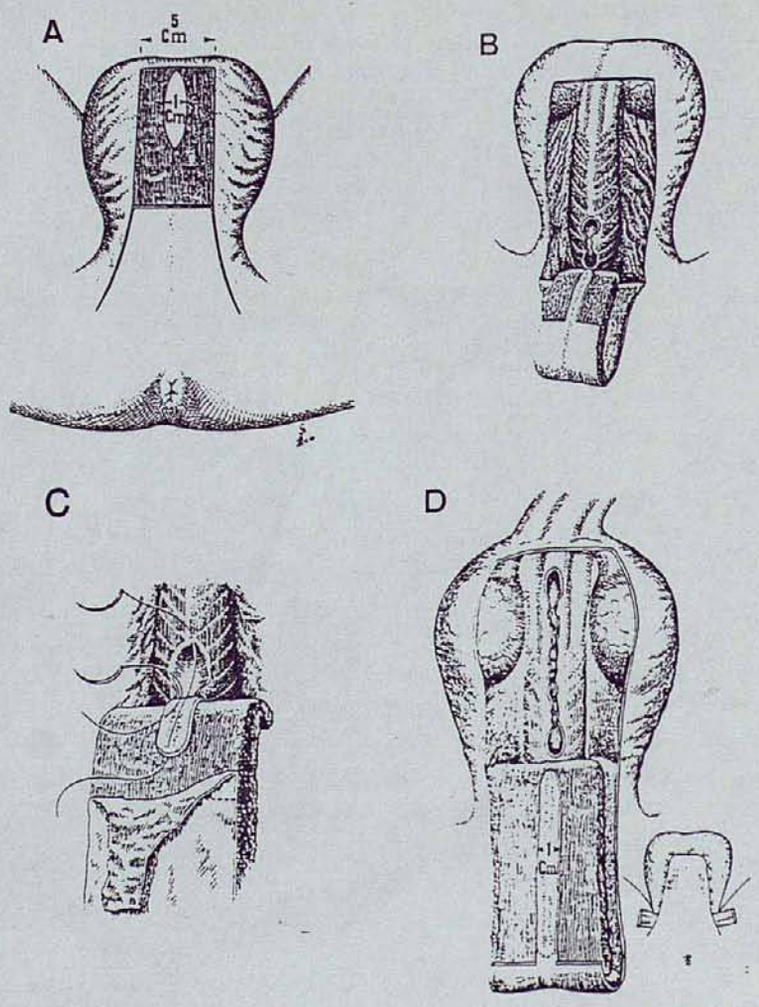

FIG. 11. Island patch urethroplasty. *A*, central cutaneous island is created before raising biaxial flap. *B*, island patch is sutured to bulbomembranous urethra. *C*, patch base is de-epithelialized and suture is completed with distal end of excised urethra. *D*, reconstruction of whole bulbar urethra with longer flap.

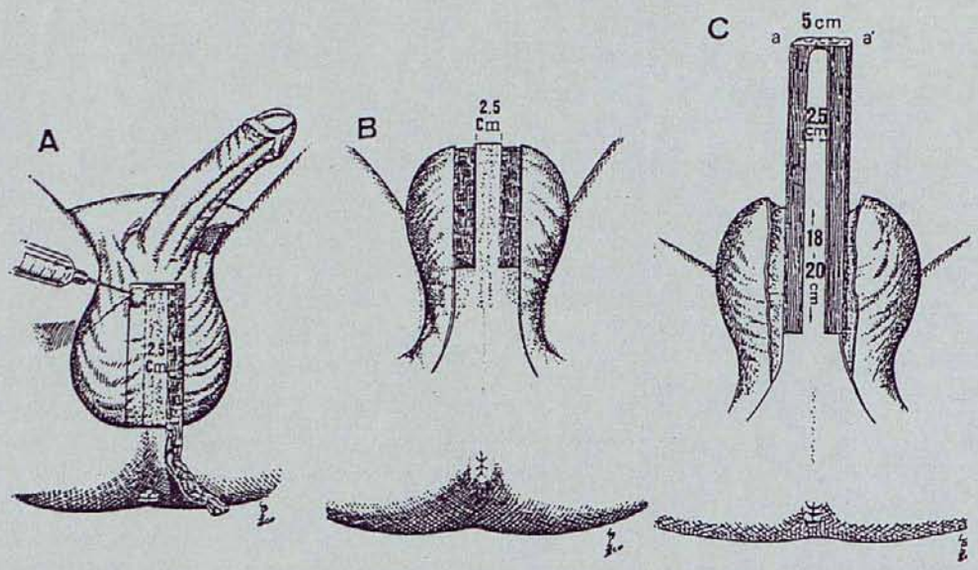

FIG. 13. Total urethroplasty with de-epithelialization of flap to obtain central skin patch. *A*, commencement on anterior scrotal face. *B*, completion on posterior scrotal face. *C*, raising extensive biaxial flap obtained from both faces of scrotum with central skin patch.

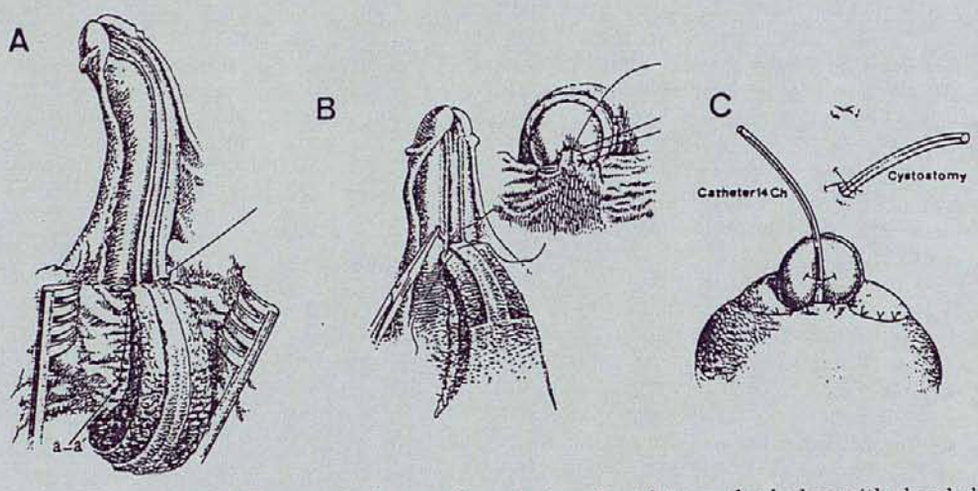

FIG. 14. Total urethroplasty with suture of skin patch. *A*, ascending suturing of patch to urethral edges with absorbable 5-zero interrupted stitches. *B*, suture is terminated, reconstructing urethral meatus. *C*, penis is joined to scrotum with suprapubic and urethral drainage.

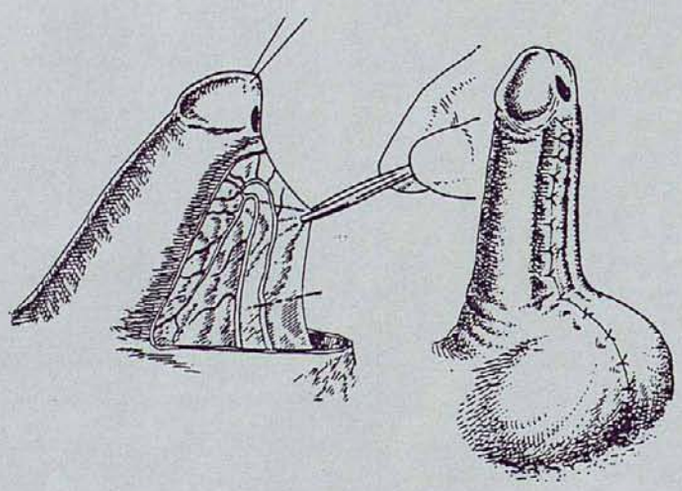

FIG. 15. Total urethroplasty showing freeing of penis. Most superficial skin vessels are sectioned until penile straightening is completed.

patch urethroplasty failed in 1 of 16 cases due to recurrent stenosis in both anastomoses and 2-stage urethroplasty was done. In 1 patient a large symptomatic flap diverticulum was repaired by resection and primary suture of the flap edges. Post-void dripping was more frequent in this type of urethro-

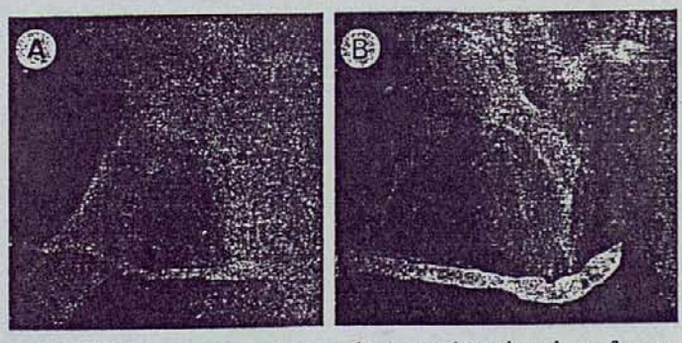

FIG. 16. Retrograde urethrography in total urethroplasty for panurethral disease. *A*, preoperative. *B*, postoperative.

plasty, and patients were instructed to support the neourethral area manually during voiding and compress it after voiding. Total urethroplasty failed in 2 of 10 cases due to graft shrinkage, necessitating perineal urethrostomy. In 1 case an incorrect epilation technique caused significant dermo-epidermal sclerosis and in the other a deep vascularization lesion occurred when the penis was released from the scrotum. Three patients required skin lengthening Z-plasty at the penoscrotal angle to relieve penile bending during erection.

DISCUSSION

In our experience, correctly epilated scrotal skin possesses ideal characteristics for reconstructive urethral surgery from the penoscrotal angle to the prostatic apex. Because of anatomical contiguity, excellent tissue availability and tolerance in contact with urine due to the abundance of sebaceous glands it is always our first option for urethroplasty. A further advantage of scrotal skin over preputial skin is its lesser tendency to develop lichen sclerosus et atrophicus.[15] The main difference between so-called dartos pedicled scrotal skin flaps and the new biaxial epilated scrotal flap is that the former are supplied only by small caliber, randomly distributed segmental vessels, which limit length and mobility (Kunert's segmental flap) (fig. 1, *B*).[4,10,16–18]

Although flaps of penile or preputial skin are currently proposed for reconstruction of the membranous and bulbar urethra in adults, we think that they have 2 major disadvantages, including the lack of contiguity with the aforementioned portion of urethra and the precariousness of a vascular pedicle lacking well-defined axial vessels. The delicate pedicle of these flaps, formed by small segmental skin branches arising from both inferior external pudendal arteries and located in penile subcutaneous tissue, must be extensively dissected and mobilized to reach the perineal scrotal area.[5,19,20] These fragile vessels become stretched and twisted, which may easily provoke peripheral cutaneous necrosis in the flap, causing retraction and fistulas.[21] These inconveniences are completely overcome by using the biaxial epilated scrotal flap for bulbar and membranous urethroplasty. At the same time, cosmetic and functional penile defects are avoided.

When separation of the urethral ends exceeds 4 to 5 cm., treatment of posttraumatic posterior urethral stenosis can be delayed.[22,23] The tubularized biaxial epilated scrotal flap permits substitution urethral reconstruction and tension-free anastomosis without the need for mobilization of the spongiosa or pubectomy. Therefore, the surgical procedure is facilitated with decreased intraoperative morbidity and late complications, such as recurrent stenosis due to spongiosa ischemia, penile retraction and curvature, and impotence, are prevented. The 20% repeat intervention rate in our patients may be attributed to the learning curve for the technique. Anastomostic stenosis due to persistence and progression of spongiofibrosis in the apparently healthy urethra was the most frequent complication. The development of pouches was only observed in patch urethroplasty. The pouches were always adjacent to the distal anastomosis and unrelated to stenosis. Thus, we considered that large diverticulum flaps may be prevented by trimming the patch width, which we have progressively decreased to 1 cm. We have not observed this complication in substitution urethroplasty with a tubular flap, since the neourethra is surrounded by a thick, solid musculocutaneous support. While penile and preputial skin flaps are ideal for pendulous urethra reconstruction, patients exist, such as those with paraplegia and extensive urethral lesions, in whom the penile skin has deteriorated due to repeated traumatic and infectious processes caused by urine collection devices. In such cases total urethroplasty using the biaxial epilated scrotal flap can be performed. Insufficient scrotal size can be resolved by the previous use of tissue expanders.

CONCLUSIONS

This new biaxial epilated scrotal flap can be used in many ways. It can be adapted to any type of stenosis, however extensive and wherever located, since it reaches any segment of the urethra without tension, twisting or stretching. Due to its excellent vascularization the risk of complications from insufficient blood supply of the reconstructed segment, such as fistulas and restenosis due to ischemic retraction, is minimal.

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EDITORIAL COMMENT

The authors have designed and illustrated clearly safe bipedicle 1-stage scrotal island flap urethroplasty based on the perineal branch of the internal pudendal vasculature. In essence, this is a scrotal fasciocutaneous flap with a reliable vascular pedicle. The authors have used it successfully in 37 patients with complex urethral strictures with 3 variations of flap transfer and a relatively short mean followup of up to 40 months. This method is an important contribution to the repertoire of urethral reconstruction when combined with careful epilation of significant hair follicles. The technique is especially applicable to proximal bulbar and bulbomembranous transsphincteric strictures or to resolution of panurethral strictures when penile skin circulation has been altered, or the amount of penile skin is limited and the periurethral recipient bed will not support the addition of a free buccal mucosal graft.

The penile island flap is the workhorse of anterior urethral reconstruction and it should be the first choice when available. Long-term results are superior to those of any other tissue transfer technique when it is used as an onlay patch in urethral stricture disease. This does not detract from the value of the scrotal island flap, which has been inappropriately maligned and can effectively resolve some of the most challenging stricture pathology. The incidence of recurrent stricture and need for revision surgery in this series was a modest 15% during the followup. The vascular anatomy of the scrotum and its relationship to the external pudendal circulation has been well described, pointing out its practical clinical significance.

Epilation, de-epithelialization and transfer of this type of skin onlay to the prostatic urethra are technically more difficult than the authors indicate. They wisely emphasize the use of a 1 cm. strip to prevent the development of a diverticulum, and show a safe perineal and scrotal incision that would prevent injury to the scrotal circulation. The concept of removing only the epithelium while preserving the dermis to prevent flap ischemia during cutaneous island flap preparation is a particularly important adjunct in scrotal flap design. This bipedicle scrotal onlay flap combined with previously described epilation methods will selectively salvage a significant group of desperate stricture problems that cannot be managed by penile fasciocutaneous flaps.

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