Grafts for One-Stage Repair

39

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Abbreviations

BXO Balanitis xerotica obliterans
PGA Polyglycolic acid
TIP Tubularized incised plate

39.1 Introduction

The use of a vascularized local penile or preputial skin has been the mainstay of hypospadias repair for a long time. If the reconstruction fails, for whatever reason, these precious commodities are irretrievably lost, and further reconstruction necessitates the recruitment of new tissue from elsewhere, generally in the form of a free graft.

Nove-Josserand in 1897 started the school of urethroplasty utilizing free grafts [1]. A free full-thickness skin graft should be used in preference to split-thickness grafts because the former have better growth characteristics in children [2]. Devine and Horton [3] and Hendren and Horton [4] had excellent results using the inner preputial skin after defattening. However, these results were not duplicated by other surgeons in a uniform manner [5, 6].

A wide variety of options has been explored. Extragenital skin from the groin, the inner arm, or the postauricular area has been used with varying success [7]. However, a widespread concern is that free graft skin is associated with fibrosis and contracture over many years. The use of the bladder mucosa was therefore embraced enthusiastically in the 1980s, particularly in view of its free availability and its compatibility with urine [8, 9]. The complication rate proved to be very high, however, partially because of metaplasia and stenosis when the mucosa was exposed to air at the tip of the penis [10–12]. Such problems were compounded by the thin and relatively weak nature of the mucosa itself, resulting in ballooning and protrusion of the reconstructed urethra with only the mildest degree of distal obstruction.

In this chapter, the three most popular techniques (i.e., preputial skin graft, buccal mucosa, and bladder mucosa) will be described in detail. Whatever technique is used, the preoperative preparation and postoperative management are the same.

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39.2 Graft Material and Graft Biology

The free graft survival passes through three stages: *imbibition* (first 2 days), *inosculation* (2–4 days), and *lymphatic drainage* (after 4–5 days).

The free graft material initially thrives by *imbibition* (diffusion of nutrients between the donor and recipient sites), and this phase lasts for 48 h. During this period new blood vessels are being formed to nourish the graft. The second phase of graft revascularization or *inosculation* occurs between days 2 and 4, and blood recirculation is re-established to the graft. By days 4–5, *lymphatic drainage* is restored. For this process of revitalization to be successful, the recipient site must be well vascularized and immobilized in the postoperative period for 7–10 days. Great care should be taken to obtain excellent skin cover to allow the graft a well-vascularized bed [13].

39.3 Full-Thickness Skin Free Graft (Wolfe)

The characteristics essential for long-term success of a free graft are efficient imbibition and inosculation, which ensure successful neovascularization and graft uptake. Full-thickness skin from non-hair-bearing areas such as (in order of the authors' preference) inner preputial skin, penile shaft, and postauricular skin has been used with success. Groin and upper arm skin have also been successfully grafted.

Although full-thickness skin grafts have a high success rate for urethral reconstruction, there are related complications such as stricture formation, graft shrinkage, balanitis xerotica obliterans (BXO), and hypertrophic scar formation at the donor site [14–18]. Moreover, the preputial or penile shaft skin may not be available in patients in whom complications from previous surgery have resulted in paucity of usable adjacent skin or in those with severe reconstructive problems.

39.4 Preputial Skin Graft

Devine and Horton [3, 19] first reported the use of the free preputial graft in hypospadias surgery. Since this initial report, the application of the free preputial graft with pedicle flap has been extended, and onlay free grafts were performed as frequently as the tubularized repairs. The technique was well described by Scherz [20].

A circumferential incision is made approximately 0.5 cm proximal to the corona, beginning dorsally, and the incision is carried ventrally down to the native meatus. After the shaft skin is completely dissected proximally to the penile base, chordee is assessed with an artificial erection. If chordee can be corrected with preservation of the urethral plate, as is often possible using dorsal plication, then an onlay free graft is used. However, when it becomes necessary to divide the urethral plate to straighten the penis, a tubularized free graft is constructed.

The graft is harvested from the inner face of the prepuce by first unfolding the prepuce and then amputating the appropriately sized graft, which has been pre-measured (Fig. 39.1a). The graft is prepared by excising the subcutaneous tissue to create a thin, full-thickness strip of skin. This step is most easily done by pinning the skin strip to a board to stretch it out. To construct the free graft tube, the skin strip is tubularized over a F10 red rubber catheter using a combination of interrupted and running 7-0 polyglycolic acid (PGA) sutures (Fig. 39.1b). The proximal end of the tube is left open as spatulation. The catheter is removed and replaced with an F8 silicone Foley. The native urethra is spatulated, and the Foley is introduced into the bladder. The balloon is inflated, and the catheter is left indwelling. The proximal end of the graft is anastomosed to the

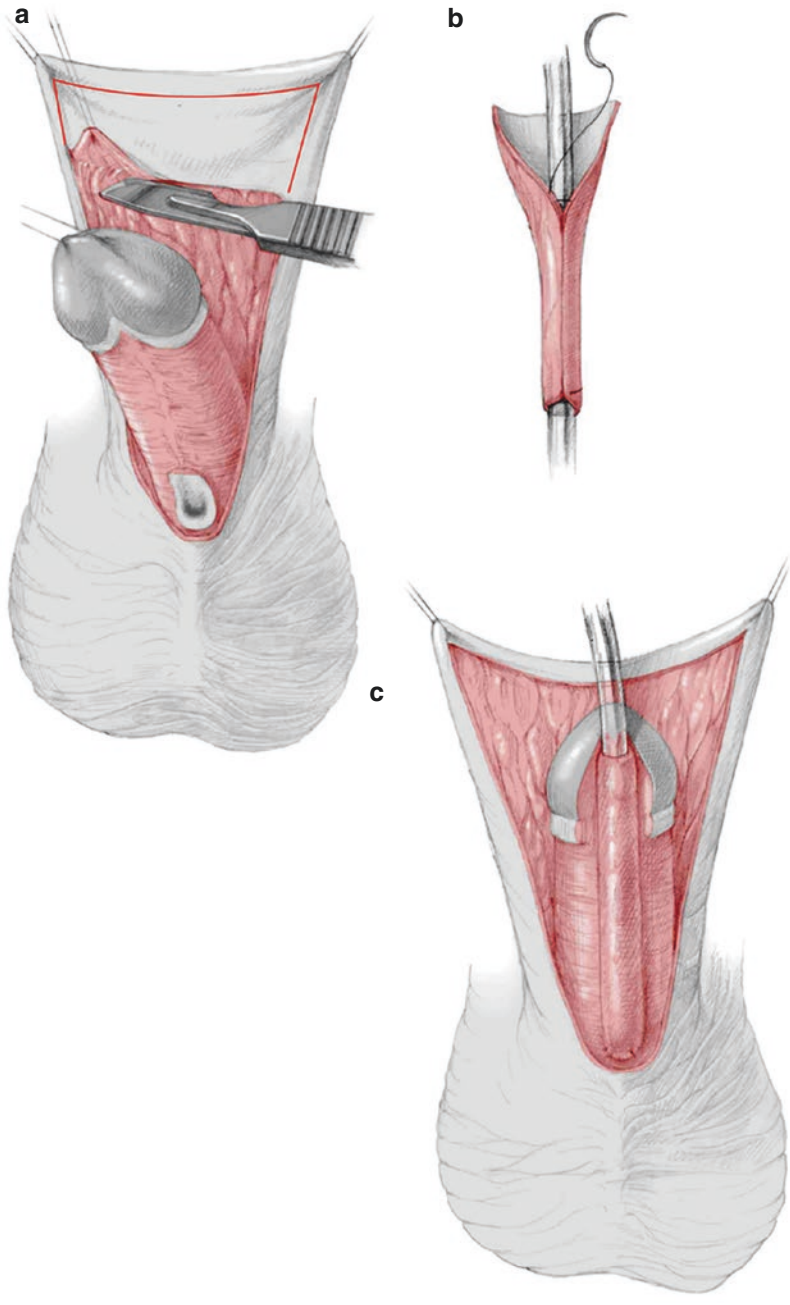

Fig. 39.1 Preputial skin graft: (**a**) elevation of the inner preputial skin. The graft is harvested. (**b**) The graft is tubularized over a F10 catheter. (**c**) The glans is split and the graft is anastomosed at both ends. (**d**) The dorsal subcutaneous flap is developed. (**e**) The protective intermediate layer is transformed ventrally and sutured in to cover the skin graft

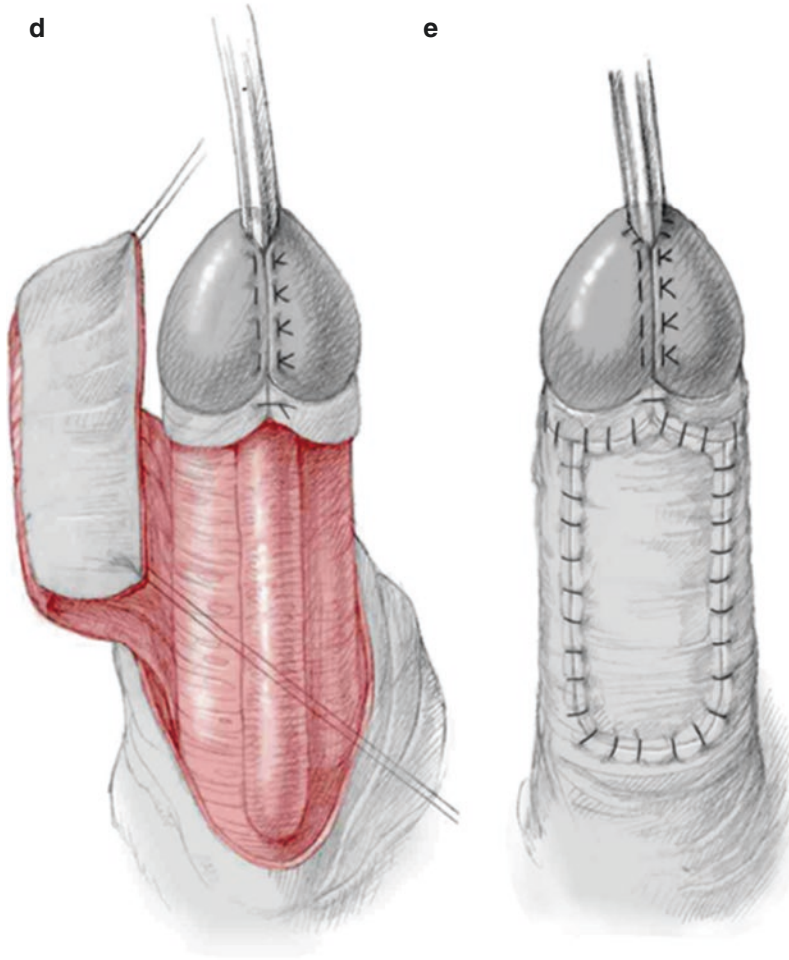

Fig. 39.1 (continued)

native urethra with interrupted 7-0 PGA suture. The tube is constructed and anastomosed so that the seam of the neourethra is positioned against the corpora cavernosa. The glans is then split, and the distal end of the neourethra is anastomosed to the glans at the glans tip, also with interrupted 7-0 PGA (Fig. 39.1c). The glans wings are brought together ventrally with several deep 5-0 PGA sutures, and the glans epithelium is closed and the remainder of the meatus secured with 7-0 PGA. Several additional 7-0 PGA sutures are used to tack down the graft to the corpora cavernosa.

The outer face of the prepuce is then used to cover the ventral skin defect by fashioning the pedicle flap. An incision is made through the dermis of the outer prepuce at the approximate level of the corona. This distal skin is mobilized on its vascular pedicle by dissecting the more proximal dorsal skin from the subcutaneous tissue and continuing the dissection to the base of the penis (Fig. 39.1d). The distal strip of the dorsal skin

that now sits on this vascular pedicle can be transposed ventrally by either rotating the flap or bringing the glans through a buttonhole in the vascular pedicle in an avascular space. The latter technique may result in less penile torsion. The pedicle is secured over the graft with interrupted 7-0 PGA, which is also used as skin sutures for the remainder of the repair. Finally, the ventral skin of the pedicle flap is trimmed to fit, and the resurfacing of the shaft is completed (Fig. 39.1e). A Tegaderm and silicone prosthetic foam dressing are applied. Both are left in place for 1 week.

When the urethral plate is preserved and an onlay free graft is used to reconstruct the urethra, the graft is sutured to the native urethra with interrupted 7-0 PGA sutures at the meatus, and each lateral border is anastomosed with a running subcuticular 7-0 PGA suture. Distally, we have used the Barcat balanic groove technique to advance the neourethra farther distally to achieve an improved cosmetic appearance.

The conditions necessary to ensure successful free graft survival were enumerated by Devine and Horton [19]. These include having a well-vascularized host bed, rapid onset of imbibition, close apposition of the graft to the host bed, immobilization of the graft, and rapid onset of inosculation. In imbibition, the graft absorbs nutrients from the host bed, and this phase lasts approximately 48 h. Inosculation involves reestablishment of vascularization to the graft by anastomosis of the exposed vessels of the host bed with the vessels of the graft. This phase is usually complete by 96 h.

Another possible reason for the good success of free graft with preputial flap may be the result of improved inosculation because the graft is sandwiched between two well-vascularized beds. The vascular pedicle also covers the repair, and this is a well-accepted technique in reducing the rate of fistula formation.

The use of the free graft repair may be relatively contraindicated when chordee is severe, and a tunica vaginalis or dermal graft is required to bridge the defect created by incision of the tunica albuginea to accomplish penile straightening. In this situation, the host bed may be unsatisfactory to support imbibition and inosculation. Patients who have had previous failed hypospadias repairs may similarly have an unsatisfactory host bed and blood supply to allow graft survival.

39.5 Buccal Mucosa Graft

Humby was the first to propose and report the use of buccal mucosa for hypospadias repair in 1941 [17]. However, the current enthusiasm for the technique was promoted by Duckett (1986) [21]. The technique has a definitive role for complex urethral reconstruction, and indeed, the success rate is so encouraging that the threshold for its use is becoming lower all the time, to the point where primary buccal graft surgery may be appropriate in some circumstances when skin resources are limited, allowing their preservation for good vascularized coverage of the penile shaft.

Buccal mucosa lines the vestibule of the mouth, which is the space between the teeth and the cheek inside the mouth. A cut section of the cheek consists, from inside out, of mucosa (epithelium), submucosa (lamina propria), musculosa (buccinator muscle), subcutaneous fat and fascia (vessels and nerves), and the skin. The function of the buccal mucosa is a direct result of its structure. A tight spinosum layer and pump-functioning cells of the superficial layer provide protection from the foreign substances placed in the oral cavity. Elastin and collagen without bony attachment give the buccal mucosa flexibility and the ability to distend and compress. A rapid turnover rate and highly vascularized lamina propria ensure quick healing after injury. The immune response is quickly aided by a lamina propria laden with lymphocytes and macrophages. Many surgeons, after harvesting the buccal mucosa graft, leave the donor area without closure,

because in reality it is too large to close without disfigurement.

Studies on the healing of grafted buccal mucosa and underlying lamina propria suggest that a similar process occurs as in bladder mucosa graft, wherein the graft undergoes partial degeneration and desquamation, followed by complete epithelial regeneration from the basal layer [22–24]. *This is in contrast to skin grafts, which maintain an intact epithelial layer throughout graft healing* [22–24]. Hence the basal layer has the capability to regenerate the epithelium. The graft connective tissue is organized by 21 days. The buccal mucosa is probably similar to the bladder lamina propria and urothelium grafts in that it is unstable before complete epithelialization, which occurs at 10–14 days, implying that the duration of graft stenting is critical and should be at least 7–10 days.

Immunohistochemistry using antibody to type IV collagen, which stains the basement membrane, has shown a vascular lamina propria, which allows efficient angiogenesis and inosculation between donor and recipient, explaining the excellent uptake of buccal mucosa [22, 23, 25]. Imbibition is efficient due to the relative thinness of the lamina propria [23, 25].

There is abundance of healthy tissue, which can be harvested with ease from the inner cheeks. However, if a long strip of buccal mucosa is required, it is preferable to harvest two strips, one from each cheek, and avoid crossing over the angle of the mouth to the lower lip. Long buccal mucosa graft harvested from the inner cheek to the lower lip usually results in scarring and deformity of the angle of the mouth. Due to the lack of luminal support of the corpus spongiosum, ballooning of the mucosal neourethra during voiding is a common occurrence. However, the elastin-rich connective tissue of the basement tissue of the buccal mucosa is relatively stiff and provides good scaffolding and prevents the occurrence of a diffuse diverticulum. Increased elastin infiltration of the buccal mucosa may explain its resilience and ease of harvest and suturing [25, 26].

Buccal mucosa, unlike the bladder mucosa, does not have the propensity for prolapse. The neomeatus remains as a vertical slit, providing a good esthetic appearance, and functionally there should be no urinary stream problems. Composite grafts of buccal mucosa and free skin graft, especially for the distal meatus, have shown improved results with regard to the adequacy of the neomeatus, good cosmesis by retaining the natural vertical glanular meatus configuration, and a good caliber, straight urinary flow in the forward direction. The main disadvantage of the buccal mucosa graft is the thick epithelial layer, which may explain its relative stiffness.

Buccal mucosa may be used as an onlay patch, as a complete mucosal tube, or in various ways combined with other free graft tissue (bladder mucosa) or vascularized skin. It may be harvested from the inner surface of the cheek or the inner surface of the upper or lower lip (Fig. 39.2). For a single strip of buccal mucosa for use as an onlay patch, the adult cheek provides up to 6 cm and the lip 4 cm at 12–15 mm of width.

Manzoni and Ransley (1999) did not recommend extending the strip through the angle of the mouth to combine both cheek and lip segments as this may cause significant contracture at the angle of the mouth [27].

The strips of buccal mucosa obtained cannot be tubularized lengthwise to create 6-cm tubes, because the width is insufficient. They can be folded lengthwise to provide shorter tubes of up to 3 cm and 2 cm, respectively, or a second graft of similar dimensions can be applied to create a full-length cylinder of adequate diameter. When

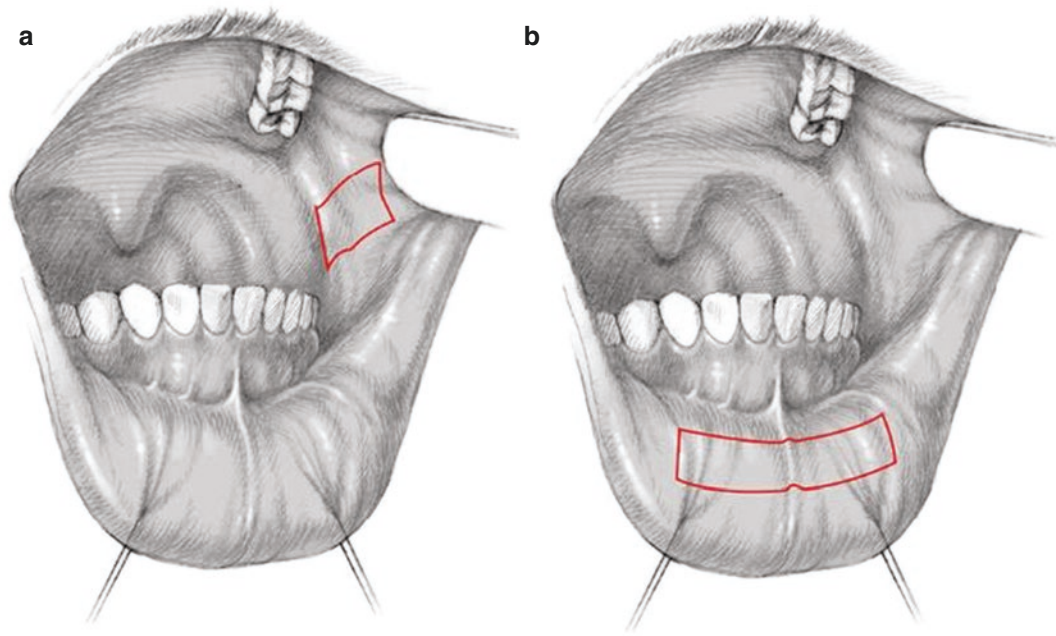

Fig. 39.2 (**a**–**b**) Harvesting of buccal mucosa

some vascularized preputial skin is available but is insufficient for tubularization, a strip may be usefully combined with buccal mucosa to form a compound neourethra. In very long urethral reconstructions, the bladder mucosa may be used successfully for the proximal urethra, reserving the buccal mucosa for the distal element and meatus.

39.5.1 Operative Technique

For a right-handed surgeon standing on the right side of the patient, the lower lip and the left cheek are the most convenient donor sites. If the requirements for the buccal tissue are clear beforehand, the buccal mucosa may be obtained before commencing penile dissection to allow an elegant uninterrupted repair that benefits the penile tissue. Otherwise, the previous repair must be dismantled, the need for buccal mucosa assessed, and the graft obtained in mid-procedure.

If a single strip of mucosa is required, the author's preference is to use the left cheek as the mucosal layer because this site is thicker than the lip and more robust than the mucosa of the lip, and the donor site is sutured primarily.

It is usually enough to use two stay sutures above and below the donor site to open the mouth. Some authors prefer to use a mouth retractor, such as the Boyle-Davis, with various sizes of tongue depressor blades. The parotid duct usually is easy to identify opposite the upper molars, and it may be cannulated with a short length of 3-0 nylon to identify it through the dissection and closure although it is usually not necessary. The graft is outlined with a waterproof pen and the submucosa infiltrated with 1% lignocaine containing 1:2000 epinephrine. Two stay sutures are placed at the posterior limit to facilitate traction. After waiting for a few minutes, the parallel upper and lower borders of the graft are incised. These incisions are then sharply angled to meet at the external limit near the angle of the mouth. One or two stay sutures are then placed to lift the graft

toward the mouth cavity, and the mucosa is dissected away by sharp dissection. Buccinator muscle inserts directly into the mucosa, and careful dissection with a knife or sharp-pointed scissors is necessary to free the mucosa. Diathermy usually is not needed, and the defect is closed with an absorbable continuous Vicryl 6/0. No further local treatment is usually necessary, and patients may eat at once.

If the buccal mucosa graft is harvested from the lip, a series of stay sutures is used to evert the lower lip and to protect the mucocutaneous junction. After epinephrine infiltration and the appropriate delay, the parallel incisions are made transversely, leaving the graft attached at either end. The mucosa (which is a little more delicate than the cheek and prone to tear) is elevated using fine tapered scissors in a manner similar to that used when creating a submucosal tunnel. Finally, the graft is released at either end and removed. The bare area is not sutured but may be packed with a temporary swab soaked in epinephrine until the end of the procedure. Healing is rapid and complete, and the scar is virtually invisible within 2–3 weeks.

The graft tissue is placed in a gauze soaked with normal saline for temporary storage, while surgery in the mouth is completed. It is then pinned out, face down, preferrable on a finger, cork, or Silastic block. Excess submucosal tissue and salivary glands are removed using a sharp scissor. After a change of gloves, the graft may be deployed in various ways.

39.6 Inlay Patch

This is the commonest approach now for using grafts. The urethral plate is incised, and the graft is applied and fixed on the well-vascularized bed using several Vicryl 6/0 sutures. The orifice of the proximal native urethra is incised dorsally to avoid proximal meatal stenosis. The graft is incised at several points to avoid accumulation of blood under the graft causing graft failure.

39.7 Onlay Patch

The urethral plate or the previously reconstructed urethra is retained as a midline strip extending forward from the normal native urethra to the glans. This strip varies in width from a few millimeters to 1 cm. The native urethra is incised for at least 1 cm proximally to create a spatulated junction. The graft is trimmed to an appropriate length and width and anastomosed to the margins of the urethral strip using 6-0 or 7-0 polyglycolic acid sutures. Glans wings are wrapped around to provide a terminal meatus. A two-layer closure of well-vascularized penile skin is advised.

39.8 Graft Tube Urethroplasty

Using either a folded graft or two segments of buccal mucosa as previously discussed, a mucosal tube is created of sufficient length to bridge the urethral defect. The proximal anastomosis is well spatulated, and glans wings are preferable to a tunnel for the creation of the terminal meatus. A two-layer skin closure follows.

39.9 Compound Tube

A compound tube technique is valuable when some preputial skin remains after earlier surgery but is insufficient for tube urethroplasty on its own. The preputial skin strip is mobilized on its own vascular pedicle and the buccal graft anastomosed to create the compound tube. This is placed in position on the ventral surface of the penis, with the vascularized skin lying against the corporal surface and the buccal mucosa lying superficially to be covered by a two-layer closure of the penile skin (Fig. 39.3).

However, this is less favorable than using a preputial graft as an inlay on the dorsal surface of the new urethra as it is easier to fix and has a better take than applying the graft in the ventral side of the neourethra.

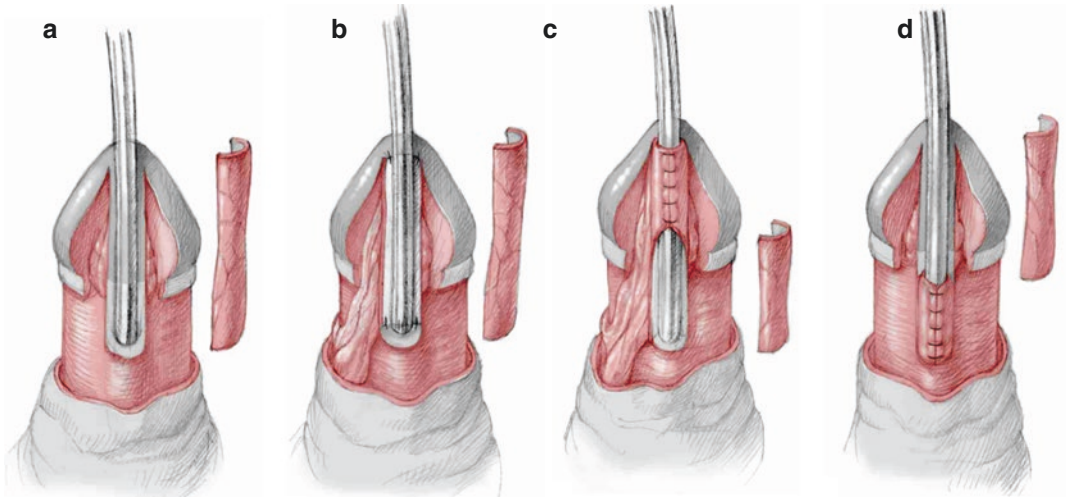

Fig. 39.3 (**a**–**d**) Some methods of urethral reconstruction using buccal mucosa

39.10 Clinical Experience and Results

Buccal mucosa is proving very satisfactory as a material for urethral reconstruction, particularly in hypospadias cripples who have undergone multiple previous procedures. It must be recognized that only short-term (5 years) follow-up has been reported. The frequency of meatal problems and urethral dilatation and ballooning is much less than with bladder mucosa.

It may be that growth factors within the mucosa promote rapid healing and that revascularization occurs quickly because of the thin lamina propria and the originally highly vascular bed from which the buccal mucosa graft was taken.

Most surgeons' experience indicate a secondary operation rate of approximately 20% [27], mostly due to minor fistulas or the need for meatal revision. In difficult cases, preoperative testosterone treatment may improve the vascularity of the penile skin and thereby enhance the chances of success with a free graft technique.

One Very Important Tip

Given the anaerobic bacterial spectrum of the oral mucosa, it is wise to institute appropriate antibiotic prophylaxis such as co-amoxiclav or metronidazole. This should be commenced prior to harvesting, to ensure effective antibiotic levels in the graft.

39.11 Bladder Mucosal Grafts

The use of bladder mucosa for the repair of the urethra in hypospadias was first described by Memmelaar in 1947 [28]. He discussed the benefits of a one-stage hypospadias repair and the favorable characteristics of bladder mucosa in the reconstruction of the male urethra.

The graft biology has been elucidated in the New Zealand white rabbit and dogs [22, 24], and the urothelium is well suited for contact with urine [25, 29–33]. However, its use in a staged urethroplasty is not feasible as the bladder

mucosa has the propensity to develop severe edema on exposure to air. It is therefore not suitable for staged urethroplasty, and there are no reports of its use in a two-stage hypospadias repair.

Bladder mucosal grafts were used extensively in China in the late 1970s for one-stage hypospadias repairs. During the past decade, bladder mucosal grafts have been used rather extensively in the one-stage repair of hypospadias and urethral stricture disease. Problems with stricture at the proximal anastomosis, along with fistulas and mucosal glanular protrusion, caused several investigators to devise ways of decreasing the complication rate. Duffy et al. used a tube of bladder mucosa combined with penile or preputial skin distally to avoid the mucosal protrusion problem [34]. Other techniques have been described to decrease the incidence of mucosal protrusion and meatal stenosis by cutting the bladder mucosa flush with the glans or even undercutting the glans epithelium and invaginating it into the new meatus. When used as a free tube graft in the posterior or bulbar urethra for urethral stricture disease, bladder mucosa has been shown to work well.

39.12 Operative Technique

Any prior failed tube graft tissue must be excised, and it may be necessary to freshen the proximal edge of the native meatus to reach well-vascularized tissue. Once the bed for the graft has been prepared and checked for good vascularity, the gap is then measured from the native meatus to the tip of the glans tunnel. Attention is then turned to the harvest of the bladder mucosal graft. The bladder is distended with saline so that it is palpable above the symphysis pubis. A Pfannenstiel incision is then performed to expose the underlying bladder. If the patient has had a previous suprapubic cystostomy, this site is avoided because of increased difficulty in obtaining a graft secondary to fibrosis. The detrusor muscle is then incised down to the underlying mucosa with a knife or blunt-tipped scissors. Once dissection reveals the bulging blue mucosa; further blunt dissection allows separation of the detrusor muscle off the mucosa for a distance adequate to harvest the appropriate-sized graft. If the mucosa is inadvertently opened before obtaining an adequate graft, the bladder can be opened, and the mucosa dissected off the detrusor (Fig. 39.4). However, this is much more tedious. Once an appropriate-sized area of the bladder mucosa is exposed, it is marked with a sterile pencil, stay sutures of 7-0 polyglactin are placed at each corner, and the graft is harvested. A suprapubic cystostomy tube is placed, and the bladder is closed in one layer with no attempt to oppose the mucosa.

The bladder mucosal graft is then tubularized over an appropriate-sized catheter using a running, inverting 7-0 polyglactin suture with interrupted sutures on one end to facilitate size trimming of the tube graft without violating the running suture. Long grafts are augmented with a second layer of interrupted sutures. Tubularization can be facilitated by placing the graft on a polystyrene needle board and immobilizing it at the ends with 30-gage needles. The

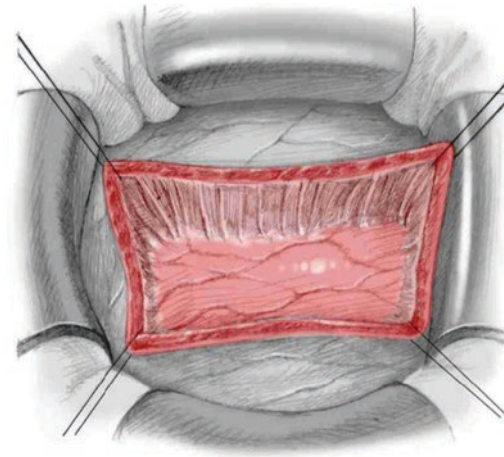

Fig. 39.4 Harvesting bladder mucosa for urethral reconstruction

graft is kept moist with cool normal saline until reimplantation. A wide, spatulated anastomosis is performed between the tube graft and recipient urethra with 6-0 or 7-0 running polyglactin suture. The graft suture line is placed dorsally against the corpora to avoid overlapping suture lines and thus decrease the chance of fistula formation. The graft can be anchored to the corpora at several points to decrease the risk that shear effect might compromise graft take. The distal end of the graft is then brought through the glans, and the bladder mucosa is cut flush with the glans edge while keeping the graft on stretch to avoid redundancy at the tip. The graft edge is then sutured to the glans with interrupted 6-0 or 7-0 polyglactin sutures. An appropriate urethral catheter or stent is placed for drainage, along with the suprapubic cystostomy tube (Malecot catheter). The graft is covered with at least two layers of well-vascularized tissues such as the tunica vaginalis, including skin. Alternatively, the bladder mucosa at the tip of the glans may be avoided by either tubularizing the distal skin strip of the glans as described by King [35] or combining the bladder mucosal graft with a strip of penile skin as described by Duffy et al. [34]. The penile or preputial skin may be closed using Byars flaps. The urethral and suprapubic catheters are connected to gravity drainage, and the penis is secured to the anterior abdominal wall with dressing to immobilize it and enhance graft take. In postpubertal patients, diazepam or estrogen can be used to prevent erection in the postoperative period. The urethral catheter is removed on the 12th to 14th postoperative day and the suprapubic tube capped. Once the voiding trial is deemed successful, the suprapubic catheter can be removed.

39.13 Results

In Keating et al.'s extensive review of the literature related to bladder mucosa grafts, an overall complication rate of 40% was found [12]. Two thirds of these complications were minor, with little or no treatment being deemed necessary. The majority of complications involve protrusion of the graft mucosa at the meatus with or without stricture. This troublesome complication has been dealt with in numerous ways, including cutting the graft flush at the glans tip, avoiding any redundancy. Others have proposed undercutting the glans epithelium and laying the edge into the distal anastomosis. Early and frequent dilatations of the neomeatus have also been proposed to help avoid stenosis. The problem with exposed bladder mucosa at the meatus is that it becomes hypertrophic, and metaplastic changes occur. Prevention of mucosal protrusion is the key to management. If mucosal protrusion or stenosis does occur, revision is necessary. Stricture at the proximal anastomosis or fistula can occur with free or vascularized flaps of all types. Urethral diverticulum of the graft tissue can occur if redundant tissue is not excised or distal obstruction is present. Stricture of the proximal or distal end of the graft may be treated with dilation or internal urethrotomy. Although bladder mucosa grafts have had a relatively high incidence of minor complications in the early postoperative period, they have succeeded well in the long run. The bladder mucosa is a good graft tissue for the urethra and has been shown by many investigators to work well.

39.14 Editorial Comment

Dorsal inlay of the preputial inner mucosa after incising the urethral plate is gaining popularity in an attempt to benefit from the slit-like meatus achieved with TIP and avoid the common complication of stenosis and urethra that is commonly encountered after the classic TIP procedure (see Chap. 27: Dorsal Inlay TIP).

The buccal mucosa remains an important source of urethral epithelium when the patient is already circumcised or when there is an inadequate or scarred foreskin for use in complicated hypospadias. It is popular because of its ease of harvest, thickened epithelium, and thin lamina

propria when compared with the bladder mucosa. Moreover, the fact that the bladder need not be opened makes the morbidity of surgery for buccal mucosal grafts less than that involved in obtaining bladder mucosa. The bladder mucosa is rarely used nowadays in hypospadias surgery.

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