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Abbreviations

GAP	Glans approximation procedure
MAGPI	Meatal advancement and glanuloplasty technique
PDS	Polydioxanone suture
TAP	Tunica albuginea plication
TD	Thiersch-Duplay
TIP	Tubularized incised plate

24.1 Introduction

In 1869, Professor C. Thiersch reported that in 1857 and 1858, he had tubularized the urethral plate to form a urethral canal in a child born with epispadias [1]. He credited the technique to August Brauser, his one-time assistant. Thiersch's classic article illustrated the design of the flaps

and the asymmetric lateral incisions so that the urethral suture lines are unopposed (Fig. 24.1).

In 1874, Duplay described the tubularization of the urethral plate distal to the urethral orifice [3]. His first successful hypospadias repair with this technique was achieved in five stages. In 1880, Duplay observed the capacity of the urethral plate to tubularize over a catheter. He wrote:

Although the catheter is not actually covered entirely by skin, I am convinced that this has no ill effect on the formation of the new urethra; stricture formation does not occur so long as half of the urethral wall is supplied by skin.

This concept was popularized by Denis Browne in 1949, when he described the buried skin strip method for hypospadias repair [4]. However, historically, Liston in 1837 described in his book *Practical Surgery* the repair of epispadias in a 23-year-old man similar to that of Thiersch in 1869 [5].

Mettauer first reported the concept of skin chordee in 1842 [6], and subsequently D.R. Smith reported it in 1967 [7]. In 1968, Allen and Spence utilized the technique of degloving the penile skin and performed foreskin transposition to correct coronal hypospadias with moderate to severe chordee [8]. King (1970) incorporated the concepts of Mettauer and Thiersch-Duplay to correct midshaft hypospadias and brought the meatus to the coronal sulcus [9].

In the early years, glanular and subcoronal hypospadias were often not repaired, because the complications of repair often overshadowed the

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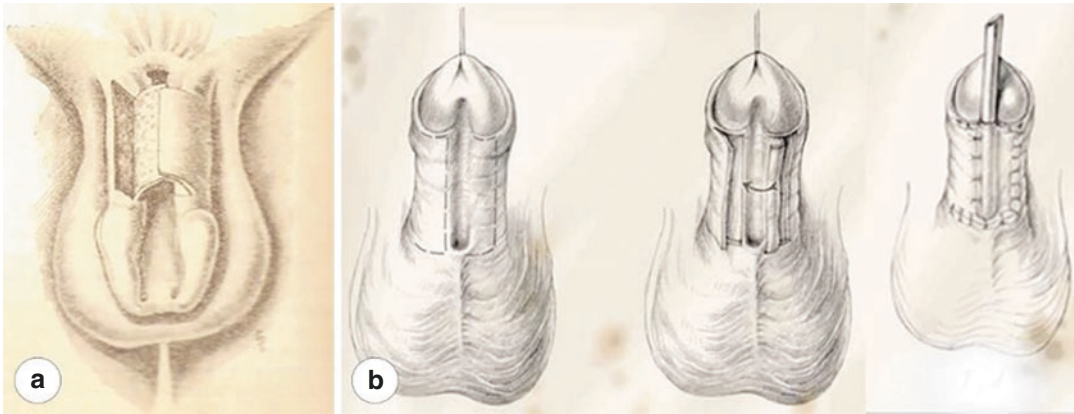


Fig. 24.1 (a) Artist reproduction of the original drawing from Thiersch for epispadias correction [1]. (b) Artist reproduction of Anger modification of the Thiersch principle to correct hypospadias [2]. Notice that the incisions

are not symmetrical so that the urethral incision lies to the right of midline and the skin closure lies to the left of the midline (©Ahmed T. Hadidi 2022. All Rights Reserved)

benefits of surgical correction. Duckett's meatal advancement and glanuloplasty technique (MAGPI) was designed to reduce the risks of formal urethroplasty in distal hypospadias [10]. Time and experience demonstrated that this technique could not be universally applied to all patients with distal hypospadias. Arap et al. modified the MAGPI technique to repair a more proximal meatus [11]. Decter described the technique of an "M inverted V" glanuloplasty and utilized the principle [12, 13]. Both Arap's and Decter's methods were designed to reduce the chance of meatal retraction, which is sometimes seen after conventional MAGPI repair, and to improve the cosmetic result of the glans penis. However, neither achieved wide acceptance.

Zaontz, in 1989, applied the Thiersch-Duplay principle to the repair of distal hypospadias [14]. He reported excellent results with the glans approximation procedure (GAP). The operation was indicated for patients with coronal or glanular hypospadias, deep glanular groove, and a fish-mouth meatus. The GAP eliminated the ventral glanular tilt, meatal retraction, and splaying of the urinary stream that was seen at times in meatal advancement and glanuloplasty procedures. Van Horn and Kass [15] modified King's [9] approach by extending the paraurethral incision to the tip of the glans penis and used a two-layer ventral closure of the glans penis. They found that very few

children were not candidates for this technique of glanuloplasty and in situ tubularization for the repair of distal hypospadias. They achieved better cosmetic results than with either the Mathieu or the MAGPI procedure.

In 1997, Stock and Hanna reported the largest documented series of Thiersch-Duplay repairs [16]. Combining the principles of Heineke-Mikulicz meatoplasty to widen the meatus dorsally at 12 o'clock with Thiersch-Duplay tubularization of the urethral plate, they noted a low complication rate of 2.1% in 512 children.

While some were embracing the Thiersch-Duplay principle, others looked to the meatal-based flap technique of Mathieu, which also uses the urethral plate as the dorsal wall of the urethra. In 1969, Barcat modified the Mathieu technique, using opposing epithelial flaps based at the meatus to create a neourethra and dissecting the urethral plate from its bed. He then incised the glans penis and placed the urethral tube within the newly created sulcus. With the Barcat technique, the configuration of the glans or meatus did not matter. However, the postoperative incidence of fistulae (15–20%) somewhat dampened the enthusiasm for this technique [17]. Koff et al. modified the Barcat technique and interposed a second layer of tissue over the neourethra, thus reducing the fistula rate to 2% [18]. Koff noted

that the only contraindication for this technique was in cases where a large amount of chordee was caused by factors distal to the hypospadiac meatus, whereby transection of the urethral plate was required. Barthold et al. reported their experience with 295 cases in 1996. All of these surgical modifications, including the Mathieu technique, share the inherent potential complications of raising and rotating a random skin flap.

Midline incision of the urethral plate was first reported by Reddy in 1975 [19]. He performed the incision to excise “fibrous tissue” in the midline that he believed to be the cause of the chordee. He then combined this with the Thiersch-Duplay principle and tubularized the urethral plate. Orkiszewski in 1987 published the technique of incising the urethral plate and called it *the dead man jacket* as he used this principle with his dead uncle when he incised his favorite jacket in the back to be able to close it in front [20]. Rich et al. described a technique for the creation of a normal vertical slit-like meatus by hinging the distal urethral plate longitudinally in the midline [21]. This modification was applied to a variety of meatal-based flaps and achieved excellent cosmetic results. In 1994, Snodgrass reported on the technique of a tubularized incised plate urethroplasty (TIP) for distal hypospadias [22]. A deep sagittal incision of the urethral plate was made from the meatus to the tip of the glans penis. This incision facilitates tubularization of the plate and results in a normal slit-shaped meatus. Furthermore, the deep incision prevents tension on the ventral suture line, thus acting as an internal relaxing incision. Hinging allows the urethral plate to be tubularized even when its width would ordinarily be inadequate to construct a neourethra of sufficient caliber.

We find the Thiersch-Duplay procedure offers several advantages. It utilizes the tissues that were embryonically destined to form a urethra; there is minimal disturbance of the blood supply of the urethral plate, which is often well vascularized; there is hardly any contracture of the tubularized plates; and stricture formation is indeed a rare complication.

24.2 Preoperative Evaluation

A routine urologic history is taken and physical examination conducted. Questions regarding maternal prenatal history and family history of hypospadias are also asked.

On physical examination one notes the position of the urinary meatus and quality of the perimeatal skin, the depth of the glanular groove, presence and degree of chordee, penile torsion, penoscrotal transposition, and whether the child has been circumcised. The presence or absence and the location of the testicles are recorded, and if undescended testicle is diagnosed in conjunction with any degree of hypospadias, intersex workup is requested.

In children with proximal and especially in perineo-scrotal hypospadias, voiding cystography is recommended, as we encountered a significantly large prostatic utricle in approximately 25% of children. We also encountered vesicoureteral reflux in 15% of the patients we studied (unpublished data).

We currently perform surgery when the patient is 6 months old. In the child with a small phallus, 50 mg of testosterone is given intramuscularly 3–4 weeks preoperatively.

24.3 Selection of Patients

We began using the Thiersch-Duplay principle in 1987 for children with a meatus at or just proximal to the coronal sulcus. When the meatus was stenotic, or a prominent shelf was encountered, we performed a Heineke-Mikulicz meatoplasty at 12 o'clock. Our experience in 512 consecutive cases was reported previously [16]. We have subsequently extended the use of the Thiersch-Duplay technique to proximal hypospadias with chordee due to skin tethering or mild chordee (<30°), due to corporal disproportion, which was corrected by the Nesbit procedure [23] of tunica albuginea plication (TAP) [24]. Early in our series, the absence of a deep glanular groove and/or the presence of hypoplastic thin skin at the urinary meatus were considered contraindications to the Thiersch-Duplay technique. The addition of

the Reddy-Rich-Snodgrass incision of the urethral plate and distally in the glans penis allowed for repair of hypospadias in children with a shallow or minimal glanular groove. Currently in our practice, the only contraindication to the Thiersch-Duplay repair is the presence of moderate or severe ventral chordee of $>30^\circ$, due to corporal disproportion. In such cases we divide the urethral plate and place a dermal graft to lengthen the ventral wall of the corpora, rather than shorten the dorsal walls by the Nesbit or the TAP procedure.

24.4 Operative Technique

A 5/0 proline or silk stay suture is placed in the glans penis dorsal to where the future meatus will be. If the meatus is stenotic, a longitudinal midline incision is made at 12 o'clock. This incision is closed transversely in a Heineke-Mikulicz fashion with interrupted 7-0 polyglycolic suture (Fig. 24.2a). An 8-F feeding tube is inserted in the urethra. If the perimeatal skin is thin and hypoplastic, an incision is made ventrally until a healthy skin is seen. The incised skin edges are then approximated with interrupted 7-0 polyglycolic sutures (Fig. 24.3). A subcoronal incision is made dorsally, laterally, and ventrally around the meatus; the width of the urethral plate is 12 mm, leaving 2 mm of skin around the meatus (Fig. 24.2b, c). The skin and dartos fascia are dissected circumferentially proximally, and the penis is degloved. In some cases deep dissection of the penoscrotal junction is necessary to completely straighten the penis. An artificial erection test is performed by placing a vessel loop as a tourniquet around the base of the penis, then injecting the corpora with normal saline. In the case of residual mild curvature $<30^\circ$, we used to use the Nesbit procedure or TAP modification. However, we have recently adopted the Baskin et al. method for chordee repair [25]. If the glanular groove is deep, we find it unnecessary to incise the glans penis on either side and prefer to denude the skin by excising two wedges of glanular skin on either side, similar to the GAP (Fig. 24.4). If the glanular groove is inadequately shallow, we incise the

glans penis in the midline at 12 o'clock to avoid any tension on the ventral suture line. The feeding tube is then removed, and either a silastic urethral catheter or a silicone splint of appropriate size is placed and secured. The urethral plate is then tubularized over the catheter using a running subcuticular 7-0 polydioxanone suture (PDS) (Fig. 24.2d). A dartos flap is raised, mobilized from the dorsal penile skin, and then rotated and sutured to cover the urethral suture line. The glanular skin is approximated with horizontal mattress-interrupted 7-0 polyglycolic sutures (Fig. 24.2e). For resurfacing the penis, we often adopt Byars flaps, which create a midline ventral raphe [26]. However, the available skin and its blood supply dictate the final closure (Fig. 24.2f). DuoDerm dressing is applied around the penis and secured with Opsite transparent adhesive. The catheter drains into a double diaper, and the child is discharged the same day. In distal hypospadias repair, a catheter is seldom used, but for proximal repairs, the catheter and dressing are necessary and are removed 3–5 days postoperatively. Prolonged urinary drainage is frequently associated with catheter obstruction and bladder spasm, which only serve to complicate matters.

24.5 Results

The Thiersch-Duplay principle with or without hinging of the urethral plate is now widely accepted and practiced by many surgeons.

The main complications in the reported series are urethrocutaneous fistula and stricture formation. Table 24.1 summarizes the surgical morbidity in the largest reported series of cases using the Thiersch-Duplay principle. It is inevitable that there are subtle variations of the surgical technique, and these are hard to quantify. However, in our experience, the major factors that determine success and complications are primary vs reoperative repair and distal vs proximal hypospadias. In comparing our early series (1987–1994), which included 512 children with distal hypospadias (coronal or juxtacoronary meatus), with our second series of 265 children with proximal

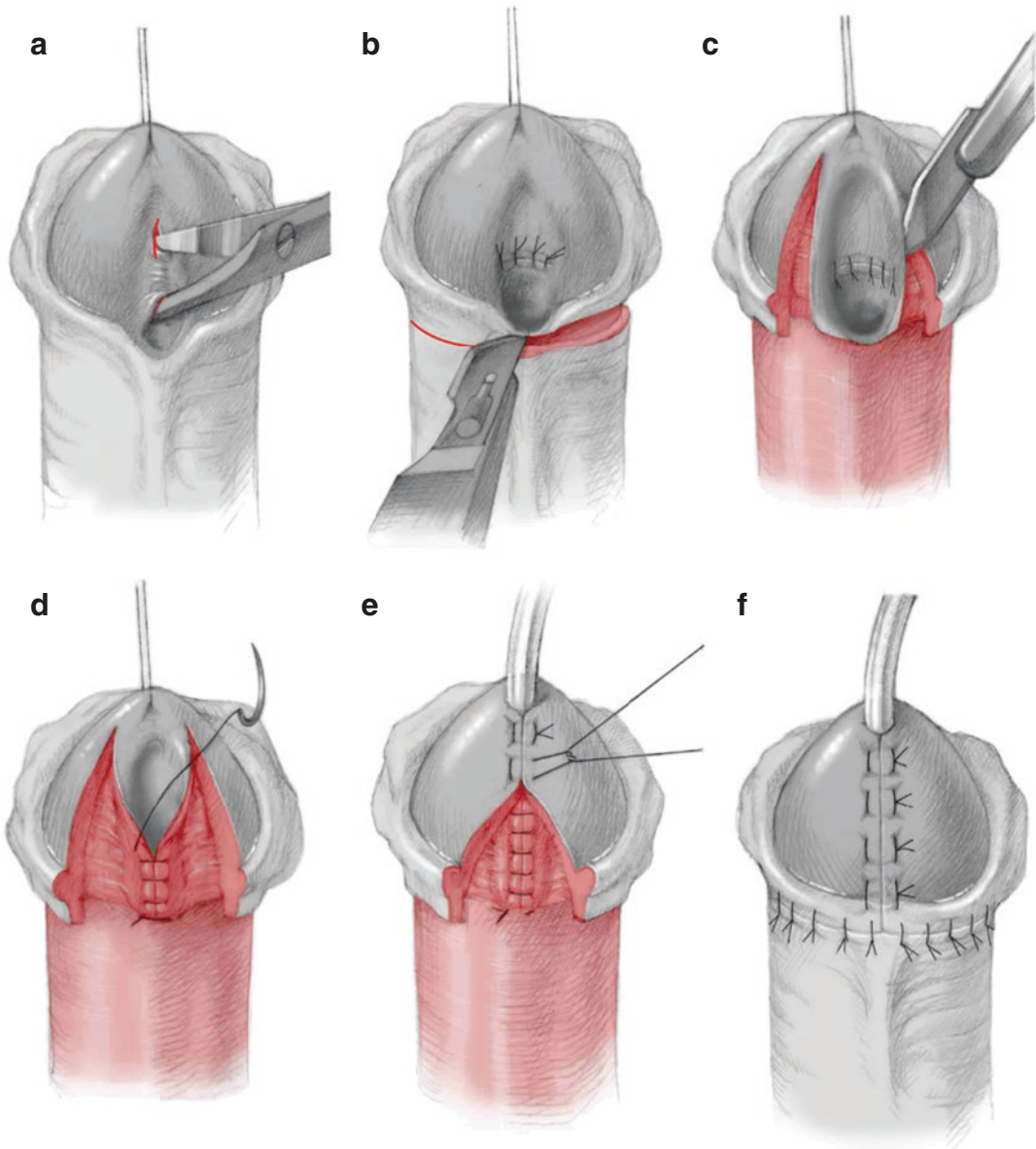


Fig. 24.2 Diagrammatic illustration of the Thiersch-Duplay repair of distal hypospadias: (a) A longitudinal midline incision is made at 12 o'clock. This incision is closed transversely in Heineke-Mikulicz fashion. (b) A subcoronal incision is made around the glans penis. (c) An incision is made dorsally, laterally, and ventrally around

the meatus; the width of the urethral plate is 12 mm, leaving 2 mm of skin around the meatus. (d) The urethral plate is tubularized over the catheter using a running suture. (e) The glanular skin is approximated with horizontal mattress interrupted 7-0 polyglycolic sutures. (f) The available skin and its blood supply dictate the final closure

hypospadias (penile, midshaft, and penoscrotal meatus), it became apparent that surgical complications were more often encountered (8.6%) in proximal than in distal repairs (2.9%).

The interposition of a healthy de-epithelialized skin flap, as described by Durham Smith, reduces the incidence of urethrocutaneous fistula [27]. We often raise a dartos flap from the dorsal penile

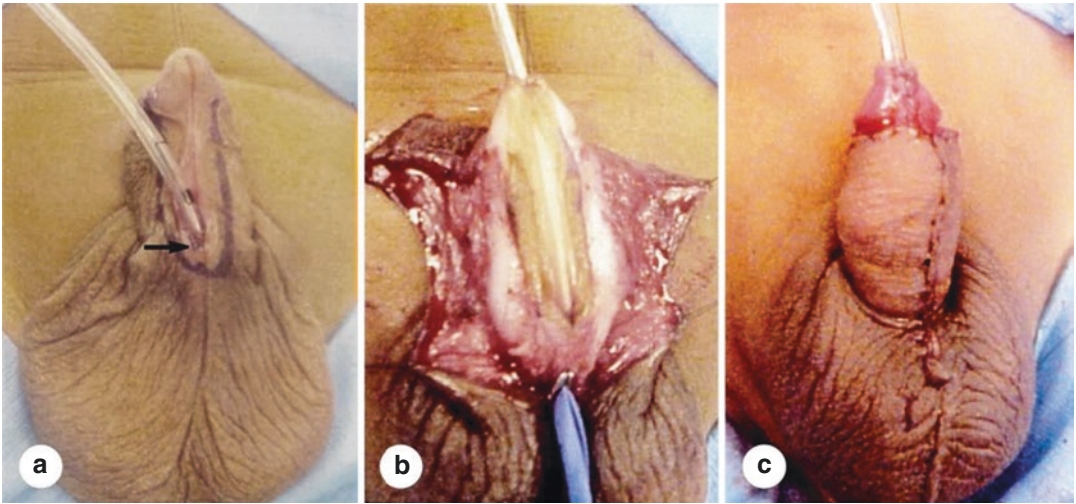


Fig. 24.3 Thiersch-Duplay repair of proximal hypospadias: (a) Penoscrotal hypospadias and hypoplastic meatal skin: Ventral meatoplasty at 6 o'clock. (b) Lateral skin incisions and denudation of glanular skin on either side of

the deep glanular groove. (c) Completed repair: The suture line is covered with dartos flap prior to skin closure

skin and rotate it to cover the ventral urethral suture line (Fig. 24.5).

The dartos or tunica vaginalis flaps provide excellent support to the suture line, especially when a ventral meatoplasty is contemplated. The routine use of a dartos flap or tunica vaginalis flap to waterproof the suture line has resulted in a significant decrease in our fistula rate from 17% to 1.8% in a series of 265 proximal hypospadias repairs [28].

24.6 Conclusion

Hypospadias surgery provides ample opportunity for modification by any surgeon who wishes to establish his individuality. Some authors claim originality of idea, but it behooves us all to credit those who pioneered current surgical concepts and principles, thus preserving our surgical heritage. We submit that the Thiersch-Duplay principle represents the basic foundation for all the surgical methods that utilize the urethral plate to construct a urethral tube.

24.7 Editorial Comment by Mark R. Zaontz

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24.8 History

While preparing to perform a Thiersch-Duplay urethroplasty on a child presenting with coronal hypospadias with a megameatus appearance, a deep wide glanular groove, and noncompliant meatus, it occurred to me that by simply approximating the glans with my fingers, a normal-appearing phallus resulted. Hence at the time, I believed that by simply de-epithelializing the

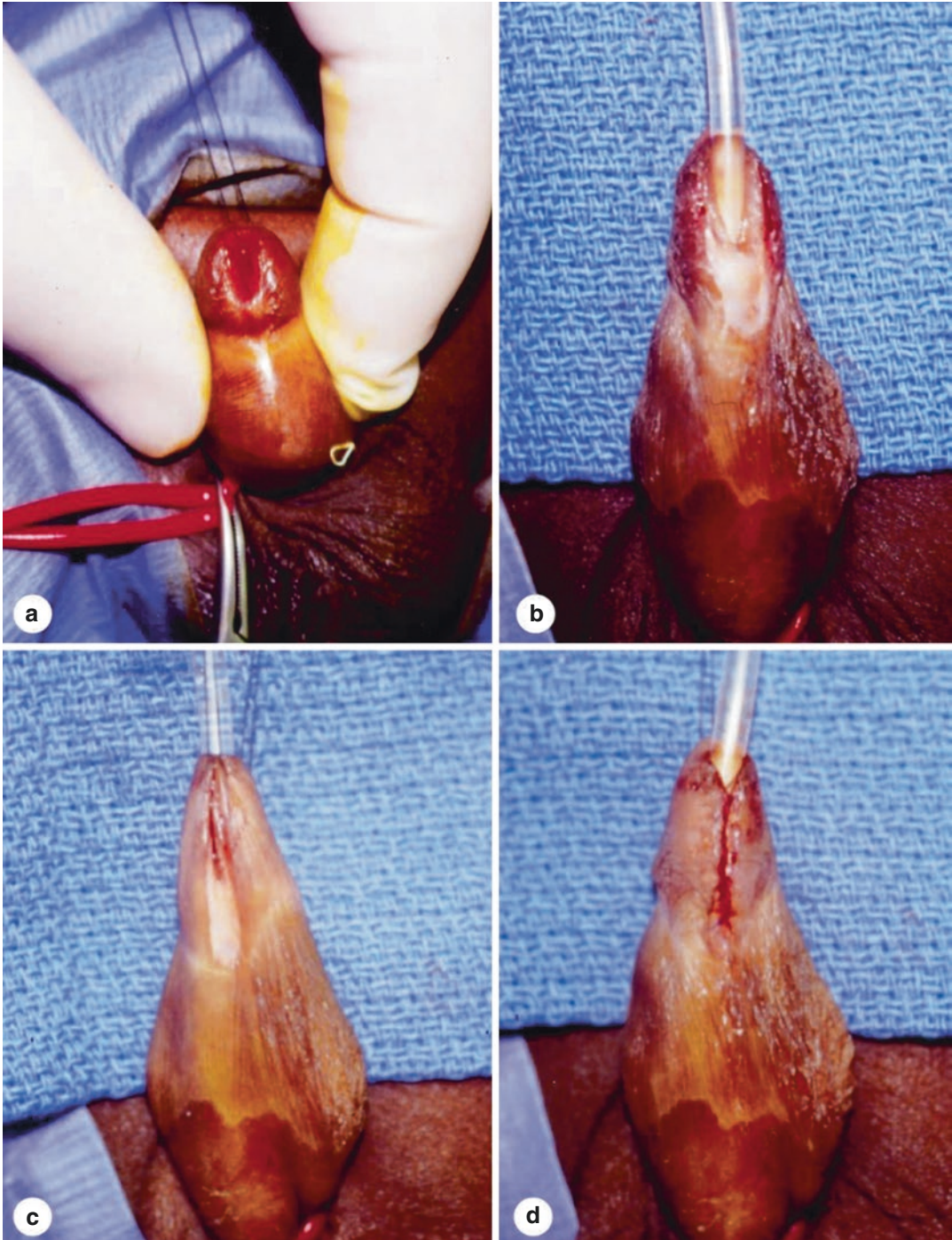


Fig. 24.4 GAP procedure: (a) Megameatus with deep groove. (b) Glanular skin is excised on either side. (c) The urethral plate is tubularized using continuous subcuticular sutures. Note the placement of ventral stay sutures aligns the tissues. (d) Skin closure using horizontal mattress sutures

Table 24.1 Surgical morbidity in the major reported series of patients operated on using the Thiersch-Duplay principle

References	Number of patients	Primary vs secondary repair	Location	Complications	
				Meatal stenosis	Fistula
Zaontz (1989): GAP [14]	24	Primary	Coronal 11, proximal 13	0	1
Kass (2000): glanuloplasty (no hinging) [29]	308	Primary	Coronal/glans 84%, midshaft 9%, prox./ penoscrotal 7%	Diverticulum 2 (0.6%)	28 (9.1%): Distal 6.2%, mid. 17.9%, proximal 42.9%
Snodgrass et al. (1996) [30]	148	Primary	Distal	3	Fistula 5, glans dehiscence 3
Ross and Kay (1997) [31]	18	Primary 15, secondary 3	Distal or midshaft	0	0
Stock and Hanna (1997) [16]	512	Primary	Distal	2	Initial 5 (four small fistulae diagnosed after toilet training)
Steckler and Zaontz (1997) [32]	33	Primary	Distal 31, midshaft, or proximal 2	0	0
Snodgrass et al. (1998) [34]	27	Primary	Midshaft, penoscrotal	1	Fistula 1, glans dehiscence 1
Stock and Hanna (1997) [16]	265	Primary	Midshaft to proximal, penoscrotal	Stricture 3, diverticulum 2	Fistula 16, dehiscence 2
Decter and Franzoni (1998) [33]	197 (156 hinged)	Primary	Glans 52, coronal 101, proximal 44	Meatal retraction 4	Fistula 5
Dayanc et al. (2000) [35]	25	Primary 23, secondary 2	Distal 20, midshaft 11	Mid-penile 1 (primary), distal 1 (primary)	Distal 1 (secondary)
Hayashi et al. (2001) [36]	13	Secondary	Distal 5	0	Distal 1 (secondary)
Shanberg et al. (2001) [37]	13	Secondary	Distal	1	Fistula and glans dehiscence 1
Smith (2001) [38]	64	Primary	Distal 53, midshaft 11	0	0
Yang et al. (2001) [39]	25	Secondary	Distal 10, midshaft 9, proximal 4, penoscrotal 2	13 (three in patients with unaltered urethral plate and no preoperative fistula)	7 (0 in patients with unaltered urethral plate and no preoperative fistula)

glanular skin just lateral and proximal to the urethral plate and hypospadias meatus, respectively, I could, with minimal dissection, create an orthotopic urethral meatus and cosmetically complete what nature had intended. The presence of the deep and wide urethral plate and the avoidance of the need for significant glans wing mobilization without significantly increasing tissue bulking during glanular approximation made this specific anatomic configuration ideal to proceed with what became known as the glans approximation procedure (GAP) (Fig. 24.6) [14].

The procedure has evolved from its earlier alliteration where the initial approximation of the urethra was done with a single-layer running closure followed by Lambert interrupted second layer. In later years that was transformed to a double running layer watertight closure as these repairs were largely performed without urethral stents. Hence the GAP was presented as a tubeless and simple solution to repair coronal and glanular hypospadias in patients with unique anatomy and a non-compliant or fish-mouth megameatus not conducive to the MAGPI procedure.

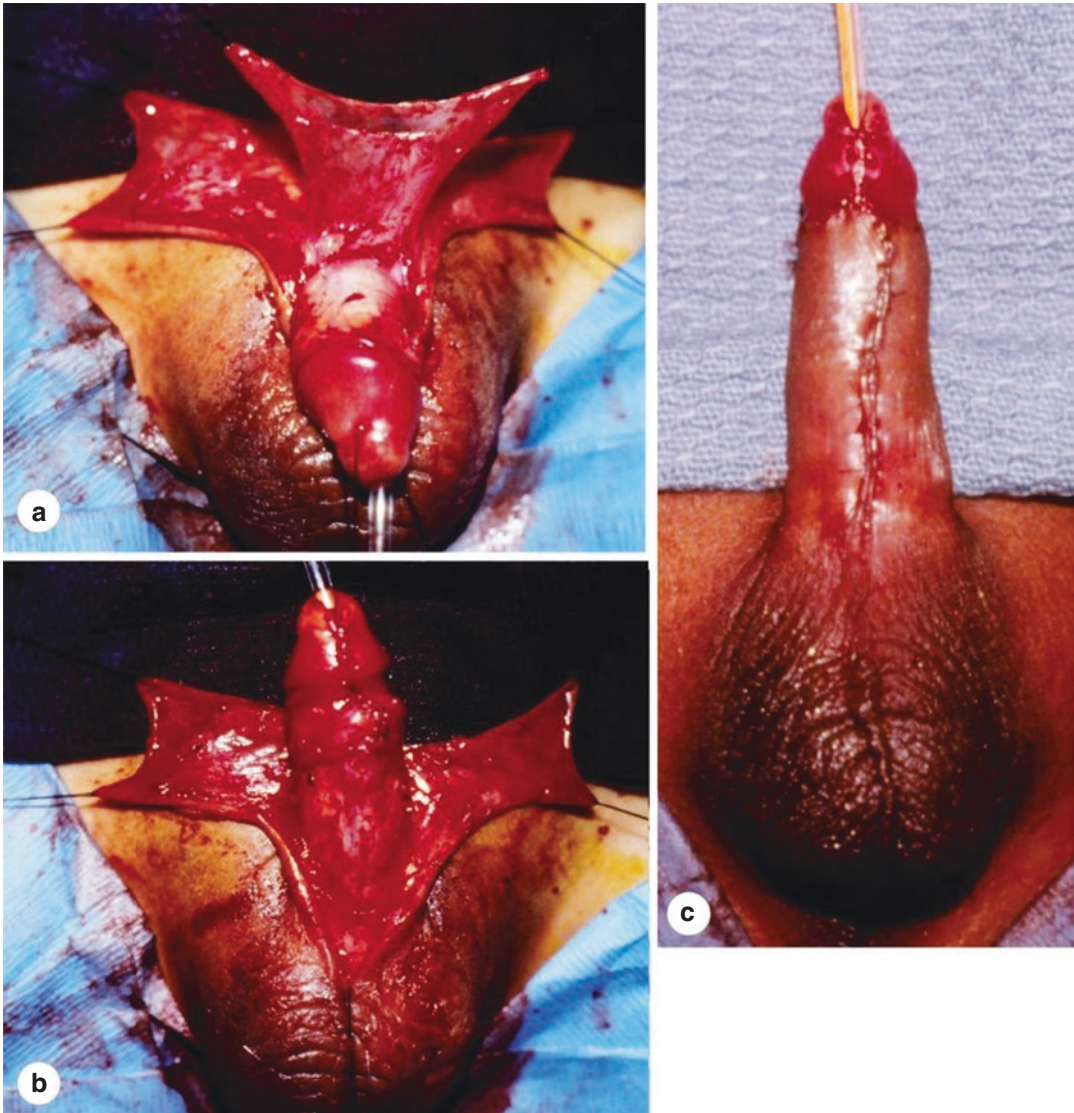


Fig. 24.5 Dartos flap and penile resurfacing. (a) The dartos flap is raised from dorsal prepuce and is dissected proximally to avoid rotational deformity. (b) The flap is rotated and covers the ventral suture line. (c) Completed repair

In my original article, I had performed 24 GAP procedures with a mean age of 1 year, 11 of which were coronal-based and 13 proximal glanular by meatal location over a 20-month time frame [14]. No urinary diversion was used and follow-up was a mean of 9 months. There was one complication, a fistula located only 2 mm from the distal glanular meatus and corrected in the office via division of what essentially was treated like a skin bridge. Overall the cosmetic and functional outcomes were excellent.

24.9 Operative Technique

This technique is a modification of the Thiersch-Duplay repair without the extensive mobilization of the glans wings. As with all tubularization techniques, care must always be taken to assess the posterior urethral plate for any transverse clefts separating the meatus for the distal glans groove. If present this cleft must be incised to flatten the urethral plate and thus avoid flow aber-

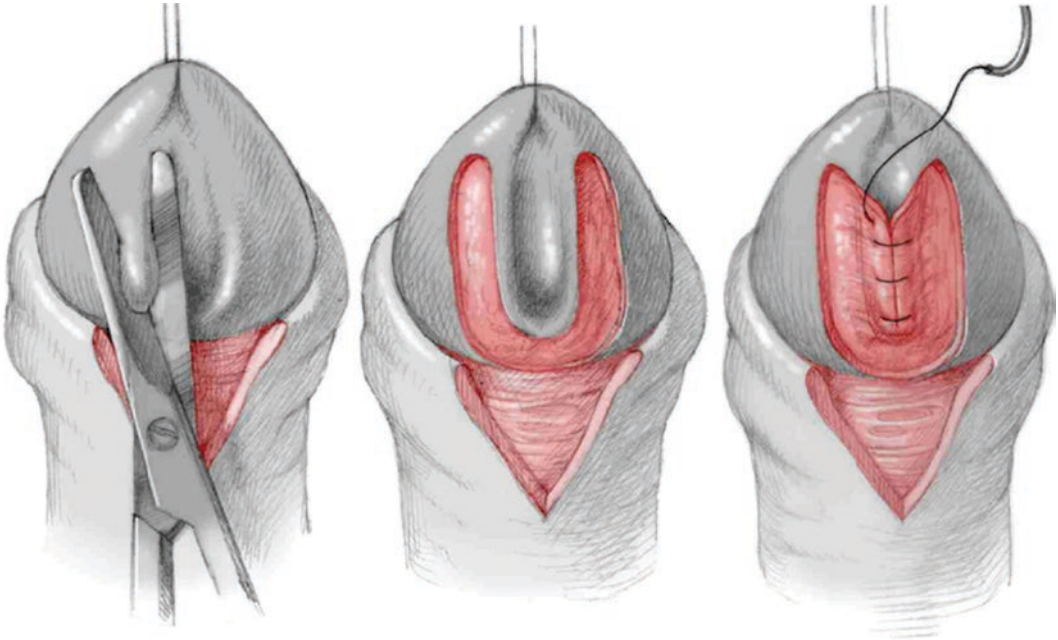


Fig. 24.6 GAP repair by Zaontz (1989) for glanular hypospadias with cleft glans [14]

rations that might otherwise occur. The lateral glanular wings just outside the border of the urethral plate is marked with a marking pen to denote the area to be incised (Fig 24.7a). Tenotomy scissors are then used to excise only the previously marked skin, thus leaving a small U-shaped de-epithelialized area of the glans (Fig. 24.7b). This denuded area is then tubularized in a double running subcuticular fashion with 7-0 polyglycolic acid suture, bringing the neomeatus to the orthotopic distal glans location (Fig. 24.7c). Because the glans groove is deep, closure of the neourethra does not significantly increase the bulk of tissue in the glans. Hence in this technique, no attempt was made to elevate glanular flaps or excise divots of spongiosum to create a tension-free glans closure performed with gentle interrupted 7-0 polyglycolic acid suture. The mucosal collar completes the repair.

24.10 Discussion and Modifications

The GAP originally was performed as a simplified version of the Thiersch-Duplay hypospadias repair without the necessity to create large glanu-

lar flaps. As noted the skin at the lateral margins of the urethral groove is simply de-epithelialized to permit approximation and healing. The ability to do this stentless added to the overall patient comfort postoperatively.

While the GAP technique provided overall excellent results in my hands with rare complications, the advent of the Belman pedicle barrier flap [41], derived from the work of Durham Smith, made me pause to rethink this. As the Thiersch-Duplay (TD) has been my “go-to” procedure for distal hypospadias with mild to moderate chordee, I began to incorporate the Belman flap in all of my TD repairs along with the aggressive glans wings dissection that I had been performing for many years since I began training in 1984. This modification of the TD has made the word fistula virtually almost disappear from my vocabulary. I began to think that it makes more sense to make sure there is extra coverage over the GAP surgical candidates to insure low surgical complication risks going forward. Hence I started to change my GAP technique to one similar to the TD repair with the addition of the aggressive glans wings dissection as well as the de-epithelialized pedicle flap popularized by

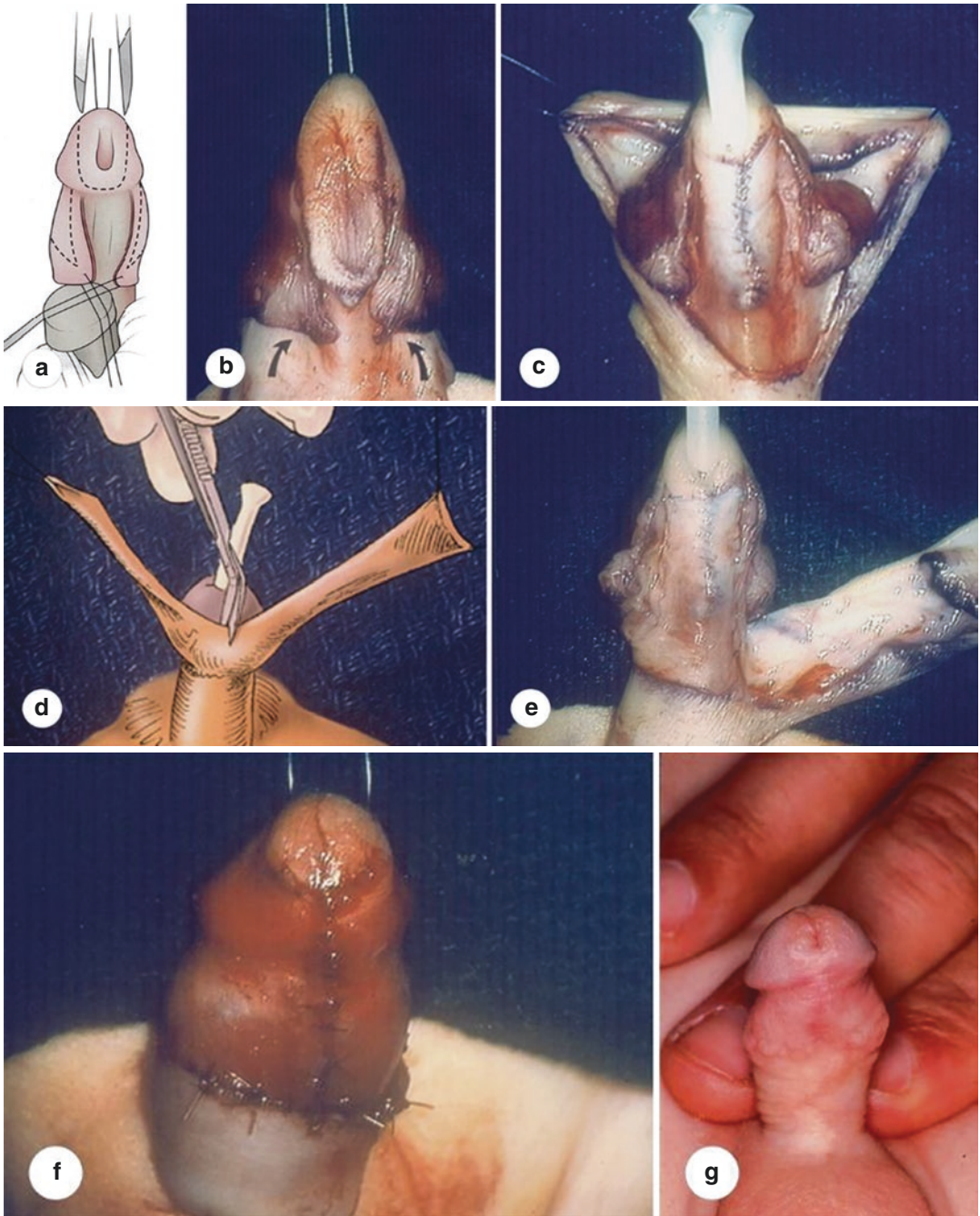


Fig. 24.7 The GAP technique modified to be used in all forms of distal hypospadias. The principle of the technique: (a) If the glans is small, preoperative hormone therapy is used to have glans width 14 mm or more. (b) The incision is designed to have a completely epithelial-

ized wide urethra. (c, d) After urethroplasty, the prepuce is incised dorsally and mobilized ventrally. (e) The preputial fascia is used as a second protective layer. (f) The foreskin is excised and circumcision is performed as published by Firlit [40]. (g) The final appearance after healing

Belman. In cases where the boy had been previously circumcised in the megameatal variant hypospadias cases, I utilize a reverse pedicle flap which essentially is a second U incision equidistant from the meatus to the location of the orthotopic meatus only done proximally. The shaft skin is de-epithelialized, and the undersurface dartos tissue is mobilized superiorly to act as a secondary vascularized layer over the neourethra. The end result is a longer suture line down the midline of the shaft that blends in with the otherwise normal line seen in the median raphe.

While testosterone use is very common in my practice at 25 mg, 5 weeks and then 2 weeks preoperatively, many of the megameatal variants have glans sizes significantly larger than 14 mm widths that would preclude its use. My experience with testosterone over the past 30 years shows that the average glans size increase in my patients who receive hormone treatment went from 11 to 17 mm with exceedingly low complication rates.

Hence since the mid 1990s, I went “back to the future” and returned to the Thiersch-Duplay principle, incorporating the vascularized secondary layer which has served me well ever since.

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