

TUBULARIZED INCISED PLATE HYPOSPADIAS REPAIR: INDICATIONS, TECHNIQUE, AND COMPLICATIONS

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Modern repair of hypospadias strives to create a penis that is not only functional but also cosmetically normal. This standard is considerably higher than were expectations in earlier years. For example, in 1917 Beck¹ described the goals of surgery met by two conditions: "1. A freely moveable urethra, permitting erection without angular deflection of the penis . . . and 2. Absolute absence of contracture or stricture of the urethra." Surveying the first generation of operative experience in correcting hypospadias, he concluded "it is not absolutely necessary to obtain a cosmetic result with smooth surfaces and a urethra in the center of the glans."¹ Seventy years later Rich *et al.*² stated that innovative techniques had been developed that did, in fact, raise hopes of achieving a normal-appearing penis. Furthermore, new procedures promising still better results continue to be added to the armamentarium of hypospadias operations, one of which, the tubularized incised plate (TIP) repair, is the subject of this review.

HISTORICAL BACKGROUND

Hypospadiology began with the most difficult cases, as the early pioneers of this reconstructive surgery generally limited intervention to boys with proximal defects. Staged repairs first straightened penile curvature and later constructed the neourethra. Although it was known in the late 1800s that chordee is associated with skin tethering and abnormal corpora cavernosal development,³ straightening was nevertheless done following recommendations dating back to the 1500s that incisions divide shortened ligaments on the ventrum.⁴ Eventually, scientific theories were formulated and widely accepted that justified this means to correct

chordee. As Creevy⁵ observed in 1958, "the urethra distal to the urinary meatus appears as a modified strip of mucosa covering a band of dense, fibrous tissues composed of abortive corpus spongiosum." Belief that this structure bent the penis led to routine excision of the tissues now referred to as the urethral plate. After straightening the penis, attention turned to creating the neourethra. Thiersch is credited with being the first to tubularize a strip of skin as he repaired epispadias. In 1874, Anger adapted his technique to a penoscrotal hypospadias, inaugurating the modern era of hypospadias surgery.⁴ At that time, preputial tissue transfers to the ventral shaft had not yet been described. Realizing there was often insufficient ventral skin to tubularize, Duplay only partially closed the neourethra, relying on postoperative epithelial growth to complete formation of the ventral aspect of the urethra.⁶ Today, the names of Thiersch and Duplay are commonly invoked whenever a neourethra is fashioned by tubularizing local skin.

The challenge of creating a functional neourethra gave rise to literally hundreds of operative techniques. As hypospadias surgery expanded to include less severe distal defects and moved to single-stage repairs, such operations as preputial free grafts,⁷ flip-flaps,⁸ and onlay preputial island flaps⁹ were popularized. A common thread in all these repairs was the need to add tissue to the urethral plate to achieve a neourethra of adequate size. Gradually, surgeons also became more demanding in their efforts to achieve a glanular meatus.

One of the greatest of all hypospadiologists was John Duckett, best known for his contributions to urethroplasty. These included the meatal advancement and glanuloplasty (MAGPI)¹⁰ for glanular hypospadias, and his interpretations of preputial flaps, which he described as onlay and transverse island pedicle flaps.¹¹ However, arguably of greater importance was his understanding of chordee. Previously, Smith¹² had observed that straightening of the penis often resulted from simply degloving the shaft skin. As noted above, surgeons in the 1800s realized that the corpora cavernosa of boys with hypospadias were sometimes maldeveloped. Yet at

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a time when the urethral plate was still often excised for chordee, Duckett insisted bending that was not corrected by release of the shaft skin usually indicated corpora cavernosal disproportion rather than tethering by the plate.¹³ He therefore advocated preserving the urethral plate, using dorsal plication to straighten mild chordee.

ORIGINS OF THE TIP URETHROPLASTY

Flip-flaps were a popular operation in the 1980s for distal hypospadias. Although this repair consistently produced a glanular meatus, the opening was often rounded, in contrast to the slit-like appearance of a normal meatus. Rich *et al.*² recognized it was the configuration of the urethral plate that actually determined the cosmetic result. A flat plate yielded a horizontal meatus, and a deeply grooved one healed with a vertical orientation. Consequently, they described "hinging" the flat plate by incising its distal aspect to improve meatal cosmesis. A few months later I extended this midline incision deeply through the entire urethral plate and realized it could then be tubularized without using additional skin flaps.¹⁴ Multicenter experience¹⁵ confirmed this finding and led to widespread interest in the technique. Then, building on the concept that the urethral plate could usually be preserved and incorporated into the repair, longer plates associated with midshaft and penoscrotal defects were also incised and tubularized.

Dorsal incision of the urethral plate returns hypospadias surgery to its roots. The neourethra is fashioned from local tissues, but in contrast to Duplay's approach, a complete tube is made intraoperatively, the dorsal surface of which is expected to re-epithelialize.

INDICATIONS

Until recently, one key to successful hypospadias repair was selection of the best technique for a given patient. MAGPI, glans approximation procedures, flip-flaps, and onlay preputial flaps each had specific indications, and use of a procedure when appropriate meatal and glanular configurations were not present sometimes yielded suboptimal results. However, TIP urethroplasty is less influenced by such considerations. In fact, it is important to emphasize that this procedure does not require a deep urethral groove, as the dorsal relaxing incision has been found to reliably widen and deepen even a narrow, flat plate.

Two contraindications to TIP hypospadias repair are severe chordee, which requires plate excision to straighten the penis, and an unhealthy urethral plate that appears thin or is insufficiently widened after incision. Because chordee is usually not

caused by the urethral plate, and the dorsal relaxing incision most often reveals supple tissues, the operation has been used successfully to correct most distal and many proximal hypospadias defects.

Since the degree of penile bending and quality of the urethral plate cannot be reliably assessed preoperatively, decision-making can no longer be done at the outset of surgery. Rather, all primary repairs now begin with preservation of the urethral plate while the penis is degloved. Only after the penis is straight and the plate has been incised is the final choice made to tubularize the neourethra or select another approach.

SURGICAL TECHNIQUE

An 8F straight sound is passed into the hypospadiac meatus to assess skin coverage over the urethra. In distal hypospadias, a circumscribing incision is made 2 mm proximal to the meatus, but if necessary, a U-shaped incision is extended proximally to healthy skin (Fig. 1). For proximal hypospadias, the lines of incision are immediately adjacent to the longer urethral plate. The penis is degloved to the penoscrotal junction.

Artificial erection is performed in every case, as even a coronal hypospadias is sometimes associated with penile bending. If mild chordee persists after the skin is released, dorsal plication is used to correct the disproportion of the corpora cavernosa. The tunica albuginea is incised longitudinally on each side just lateral to the neurovascular bundle opposite the point of curvature, and then 6-0 Prolene sutures are placed with the knots buried. Dorsal plication does not require extensive mobilization of the neurovascular bundle, excision of tissue ellipses, or transverse incision into the tunica albuginea.

Next 1:100,000 epinephrine is infiltrated into the ventral glans along the visible junction of the glans wings and urethral plate. Then the plate is separated from the glans by parallel incisions and the glans wings are mobilized laterally. At this stage, the plate is only 4 to 8 mm wide depending on its natural groove.

The key step in the operation is a midline relaxing incision made from within the meatus to the distal extent of the plate. This incision extends through the epithelial surface of the plate deeply into underlying connective tissues down to the corpora cavernosa. With the surgeon and assistant maintaining countertraction using fine forceps, division of the plate is observed to significantly widen it until further incision yields no additional mobility. Tenotomy scissors, rather than a knife, are recommended for this maneuver so

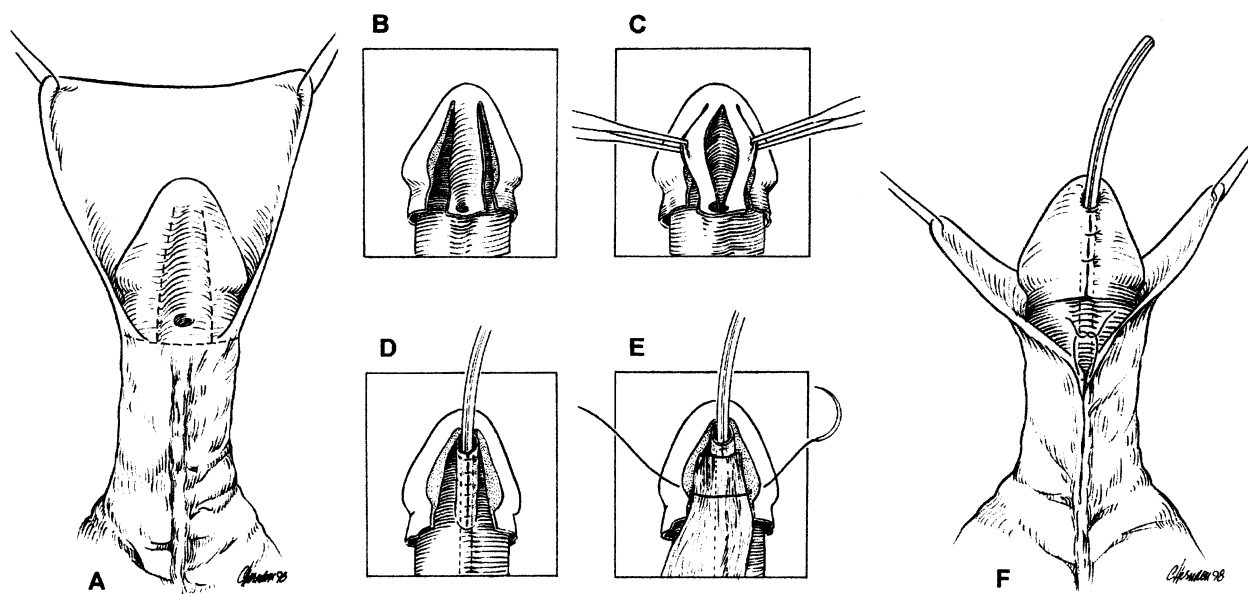


FIGURE 1. Tubularized incised plate urethroplasty. (A) Horizontal line indicates circumscribing incision to deglove penis. Ventral lines demark junction of urethral plate to glans wings. (B) Urethral plate is separated from glans wings but is too narrow for tubularization. (C) Midline relaxing incision of urethral plate is made from within the meatus to its distal extent to widen and deepen the plate. (D) Urethral plate is tubularized over 6F stent. (E) Dartos pedicle covers the neourethra. (F) Glans wings, mucosal collar, and ventral shaft are closed.

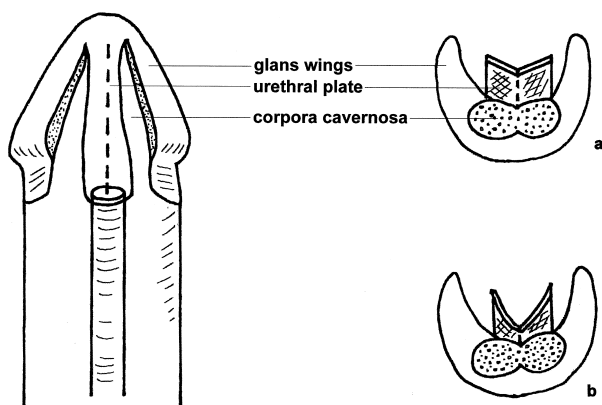


FIGURE 2. Midline relaxing incision of the urethral plate. (a) Transverse section of the midglans level demonstrates there is a greater volume of connective tissue underlying the flat urethral plate and so the incision will be deeper to reach near the surface of the corpora cavernosa than when (b) the plate already has a natural groove extending near the corpora.

as to gain adequate depth without injuring the corpora cavernosa.

Plate configuration determines the depth of this relaxing incision (Fig. 2). When the urethral plate is flat, the incision will obviously be deeper than when the plate is already naturally grooved. Some surgeons first cut the relaxing incision and then make parallel incisions to define the plate to ensure an adequate width. However, we find the dorsal incision consistently widens the plate to 13 to 16 mm regardless of its configuration, ensuring the neourethra will exceed 12F.

If bleeding occurs, 1:1000 epinephrine is dripped onto the wound and pressure is held for several minutes. These measures will usually be successful, although a tourniquet can be applied at the base of the penis if necessary. It is probably best not to use electrocautery either to incise the plate or control bleeding so as to avoid injury to the tissues of the plate and underlying corpora cavernosa.

Next, a 6F stent is passed into the bladder for postoperative urinary diversion. Then the urethral plate is tubularized. The first stitch is always placed at the midglans level and no more than one, or at most two, stitches are ever taken further distally to ensure the neomeatus has a generous oval opening. I use a single layer of full-thickness 7-0 chromic catgut sutures. Those who prefer slower absorbing suture materials, however, should consider subcuticular closures.

The entire neourethra is covered by a thin dartos pedicle mobilized from the dorsal prepuce and shaft skin. Glansplasty follows, beginning at the corona and continuing distally with a total of three stitches. It is not necessary to secure the neourethra to the glans, although fine sutures at the four and eight o'clock positions may slightly evert the meatus for cosmesis.

The mucosal collar is approximated in the midline and the shaft skin is refashioned to simulate the median raphe. Subcuticular stitches are used to prevent suture tracts that were previously noted when 6-0 chromic catgut was placed through the

skin.¹⁶ A Tegaderm dressing is applied, and the child discharged home.

It is not known how quickly the dorsal plate incision re-epithelializes or whether contact with urine during voiding influences healing. Initially, urinary diversion was maintained for 10 days after distal repairs.¹⁴ Surgeons in the multicenter studies^{15,17} left stents indwelling for 6 to 14 days according to individual preferences. In contrast, Steckler and Zaontz¹⁸ did not use postoperative diversion in boys aged 5 to 30 months and reported no adverse outcomes. Presently, I stent distal repairs for 5 to 7 days and proximal repairs for 10 to 14 days.

OUTCOMES

TIP hypospadias repair consistently produces a functional neourethra. Initially, there was some concern the dorsal plate incision would stricture. To address that question I recently reviewed the experience with the first boys to undergo the operation.¹⁹ There were 61 evaluable patients with a mean follow-up of 15 months (range 1 to 84), studied with calibrations, uroflowmetry in toilet trained boys, and urethroscopy in those anesthetized for other procedures. No strictures were detected, and the neourethra always exceeded 10F. Of interest were the findings at urethroscopy done in 7 boys, 3 of whom had had proximal repairs. In each, the neourethra appeared healthy without visible scarring from the dorsal relaxing incision.

Furthermore, TIP urethroplasty reliably creates a vertical, slit-like meatus. After surgery, most boys appear to have only been circumcised. Without doubt the operation's growing popularity is largely due to the widespread opinion that it achieves better cosmetic results than do other techniques.

The procedure is also versatile and able to correct nearly all distal and many proximal hypospadias defects. Within 3 years of its introduction, Steckler and Zaontz¹⁸ reported TIP urethroplasty to have replaced flip-flaps in their armamentarium. Retik *et al.*²⁰ found that within 10 months of first using the operation, it already accounted for 46% of all repairs done by their group and speculated its use would increase. Similarly, Franzoni and Decter²¹ first performed TIP repair in 1994, and by 1997, 82% of their patients with distal hypospadias were corrected with this technique.

Although most boys undergoing TIP urethroplasty have had distal repairs, many series have included some patients with midshaft and penoscrotal hypospadias.^{17,18,20,22} We reported the first experience using the operation for proximal repairs in 27 boys and found dorsal incision to widen the plate adequately for tubularization.¹⁷ There are even anecdotal accounts of tubularizing urethral

plates extending from the perineum (Cendron M, and Gosalbez R, personal communication, 1998). Although the ultimate role for TIP urethroplasty in proximal cases is not yet defined, we believe it is a reasonable option when chordee does not necessitate excision of the plate and midline plate incision yields adequate width.

COMPLICATIONS

Table I lists the complications encountered in the reported series of TIP urethroplasty for primary hypospadias repairs. From 0% to 7% of boys undergoing distal hypospadias surgery have experienced postoperative complications; the single report on proximal repairs noted an 11% complication rate. The most common problem in most series has been fistulas, which can largely be avoided by routine interposition of a barrier layer between the neourethra and overlying glans and shaft skin closures. This coverage is best achieved using a de-epithelialized dartos pedicle flap instead of relying on local tissue.²¹

The second most common complication has been meatal stenosis, which may result from one of several technical errors. It is important to confine the dorsal incision to the urethral plate, as extending it distally into the glans may lead to scarring. Suturing the plate too far distally will constrict the neomeatus, which should have a generous oval configuration. Similarly, care must be used during glansplasty to avoid narrowing the meatus.

Other problems such as urethral stricture, diverticulum, and wound dehiscence have occurred infrequently. Baskin *et al.*²⁴ concluded from their study of fetal hypospadias specimens that rich vascularity of the urethral plate most likely explains the tendency of the relaxing incision to re-epithelialize, creating a healthy neourethra without strictures. Because no skin flaps are added to the urethral plate, diverticula are unlikely to develop. The single patient with this complication also had meatal stenosis, which likely contributed to its occurrence.¹⁷ Adequate incision of the plate and mobilization of the glans wings should allow tension-free closure of both the plate and glans, diminishing the risk of dehiscence.

Complication rates of TIP urethroplasty compare favorably with those of other hypospadias repairs. Although Duckett and Snyder²⁵ reported problems in 1.2% of 1000 boys 2 months after MAGPI and Park *et al.*²⁶ found cosmetic results durable at 3 years of follow-up, Hastie *et al.*²⁷ noted partial regression of the meatus in 26 of 28 patients with long-term follow-up, and Mouriquand *et al.*²⁸ agree this is a possible complication of the procedure. Since the MAGPI was first described in 1981, many investigators have stressed the need to care-

TABLE I. Primary TIP hypospadias repairs

Authors	No. Pts.	Hypospadias Location	Complications					
			No. Pts.	Meatal Stenosis	Neourethral Stricture	Fistula	Dehiscence	Diverticulum
Snodgrass ¹⁴	16	Distal	0	0	0	0	0	0
Multicenter 1996 ¹⁵	137	Distal	10 (7)	3	0	5	2	0
Multicenter 1998 ¹⁷	27	Proximal	3 (11)	1	0	1	1	1
Steckler and Zaontz ¹⁸	31	Distal	0	0	0	0	0	0
	2	Proximal						
Ross and Kay ³⁰	15	Distal and midshaft	0	0	0	0	0	0
Landau <i>et al.</i> ³²	15	Distal	1 (7)	1	0	0	0	0
Sugarman <i>et al.</i> ²²	25	Distal	1 (4)	0	0	1	0	0
	7	Proximal	1 (14)	0	0	0	1	0
Retik and Borer ³¹	51	Distal and proximal	1 (2)	0	0	1	0	0
Snodgrass ^{23*}	64	Distal	2 (3)	0	0	1	1	0
	10	Proximal	1 (10)	0	0	0	1	0
Total	328	Distal and proximal	18 (5.5)	5 (1.5)	0	8 (2)	4 (1)	1 (0.3)

KEY: TIP = tubularized incised plate; No. Pts. = number of patients.

Numbers in parentheses are percentages.

* Includes patients reported in original and multicenter series.

fully select candidates for the operation to avoid meatal regression or stenosis. More extensive procedures such as flip-flaps²⁹ and onlay flaps¹³ have a similar incidence of fistulas, meatal stenoses, diverticula, and wound dehiscence, as does TIP urethroplasty.

ALGORITHM FOR HYPOSPADIAS REPAIR

Because the urethral plate usually does not cause penile bending and widens sufficiently for tubularization by midline incision, TIP urethroplasty can be used to repair most hypospadias. Severe chordee that persists after degloving the penis often leads to excision of the plate, even though other maneuvers such as dorsal plication, ventral corpora cavernosal grafting, or separation and rotation of the corpora are still needed for straightening. Urethroplasty is then most often done as a second stage, although some might prefer simultaneously constructing a transverse island preputial flap.

If the dorsal relaxing incision into the plate does not yield adequate width or the subepithelial connective tissues appear thin, all unhealthy tissues are excised and an onlay flap is used to complete the ventral aspect of the neourethra. In 92 consecutive cases, I have exercised this option once. In this boy, one side of the divided plate was exceedingly thin and, therefore, was not incorporated into the repair.

REOPERATIONS

Incision and tubularization of the urethral plate can also be useful in reoperative cases. Our first

multicenter report included 11 boys in whom the operation was successful after failed MAGPI, glans approximation procedures, and flip-flaps. Ross and Kay³⁰ performed reoperations on 3 patients who previously had undergone a flip-flap, pyramid, or onlay operation. Similarly, Retik and Borer³¹ reported good results in four reoperations, including one failed flip-flap and one onlay flap. The other 2 patients each had multiple procedures for proximal defects, resulting in a coronal meatus amenable to glanular TIP repair. Furthermore, I have redone a TIP urethroplasty in 1 boy 6 months after wound dehiscence.

In fact, the TIP repair offers unique advantages to consider for reoperations. The urethral plate often remains supple after glans approximation procedures, flip-flaps, and onlay flaps, since the medial aspect of the plate is not disturbed by these techniques. In addition, the relative lack of skin after circumcision limits development of pedicle flaps. However, the operation should not be used in these situations if the urethral plate does not appear healthy.³²

CONCLUSIONS

TIP urethroplasty is a versatile repair that can be applied to a wide range of defects encompassing most distal and many proximal cases. Regardless of the preoperative glanular configuration, the procedure reliably creates a vertically oriented meatus. Furthermore, even the initial series of boys undergoing the operation have been reported to have low complication rates similar to those of older techniques. On the basis of these results, the bar mea-

uring successful outcomes of hypospadias repair has been raised. It is now the goal of the hypospadiologist to construct a functional neourethra centered in a normal-appearing glans.

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