Vesicoureteral reflux: surgical approaches

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The treatment of vesicoureteral reflux (VUR) has evolved over the past half-century from primarily surgical to nonoperative treatments in most cases [1,2]. Although the benefits of surgical correction versus medical management are debated, the surgical techniques that have evolved are highly effective in correcting VUR. Recently, the US Food and Drug Administration (FDA) has approved an injectable implant of dextranomer/hyaluronic acid copolymer (Deflux, Q-Med, Uppsala, Sweden) for use in children, making the endoscopic treatment of reflux a potential alternative to open surgical correction [3]. This article reviews the different surgical techniques, postoperative management, and complications, as well as the various implants used in the endoscopic correction of VUR and their outcomes.

Historical roots of ureteral reimplantation

In 1952, Hutch [4] first reported the association of VUR and pyelonephritis with renal scarring in adult paraplegics. His series demonstrated that the correction of VUR in paraplegics improved hydronephrosis and prevented urinary tract infection and pyelonephritis. Society is indebted to him for the early development of the technique of ureteral reimplantation, including the importance of creating a submucosal tunnel of the ureter with detrusor muscular backing. Fortunately, it is now recognized that proper management of neurogenic bladder dysfunction in paraplegics prevents the complications his operation was intended to treat.


In 1997, the American Urological Association’s panel of the treatment of VUR published guidelines for the treatment of children with VUR [1]. This comprehensive report included a meta-analysis of all published data on the treatment of reflux. It outlines treatments as guidelines and options and states whether they are based on published evidence versus expert recommendation. Antibiotic prophylaxis is the recommended initial therapy for all children with grades I to II reflux. Only in older children (6 or more years of age) with bilateral grades III or higher was surgical correction an initial option. In all children with grades III to V reflux and persistent reflux despite a trial of observation on prophylactic antibiotics, however, surgical correction was recommended as a guideline or preferred option. Endoscopic correction was not recommended because of a lack of a safe and proven efficacious implant for injection.

Intravesical ureteral reimplantation

Intravesical ureteral reimplantation has been the standard treatment of VUR in the United States for the past half-century. Techniques can be categorized as those that require a neocystotomy or those where the ureter is advanced into the bladder through the existing ureteral hiatus. This article reviews the basic techniques of the most
commonly performed types of ureteral reimplants, but does not provide detailed surgical descriptions of the procedures.

The surgical objective of ureteral reimplantation is to create a passive flap valve mechanism that allows the ureter to occlude temporarily while the intravesical pressure rises within the bladder, therefore preventing VUR from occurring. A mucosal tunnel with a length-to-ureteral diameter ratio of 5:1 should result reliably in success rates that exceed 95% [10]. The second goal is to allow for normal ureteral peristalsis and drainage into the bladder without obstruction.

The most commonly performed ureteral reimplant involving neocystotomy, or creation of a new ureteral hiatus, is the Politano-Leadbetter reimplant. Originally reported in 1958, many hailed this as the ideal ureteral reimplant [5,10]. The submucosal tunnel length can be varied depending on the position of the neohiatus, allowing for the reimplantation of dilated or tapered ureters. The ureter is backed by detrusor that has not been reconstructed with sutures, making the muscular support for the ureter more reliable. Finally, the ureteral orifice is positioned similar to the normal anatomic path of the ureter, ensuring that retrograde catheterization of the ureter should be accomplished readily.

The initial step in this and all intravesical ureteral reimplants involves dissection of the intravesical ureter from the detrusor and retroperitoneal attachments along the plane of Waldeyer’s sheath (Fig. 1). After dissection of the ureter, the location of the neohiatus should be determined. It is important that the neohiatus be in a portion of the bladder wall that is sufficiently immobile to prevent the ureter from kinking as the bladder fills. The position of the neohiatus should be superior and medial to the original hiatus. The clamp should not be passed blindly from the neohiatus to the original hiatus, but should follow a dissection of the posterior bladder wall between the original and neohiatus, as well as dissecting the peritoneum away from the posterior bladder wall [10,11]. Failure to perform this critical maneuver risks placement of the ureter through the peritoneum and occasional intestinal injury [10,12]. A clamp is passed from the new hiatus back to the original hiatus and the ureter is pulled into the bladder at its new location. The ureter is placed through the submucosal tunnel and directed toward the bladder neck.

There are three types of ureteral advancements: (1) trigonal (Glenn-Anderson), (2) cross-trigonal (Cohen), and (3) medial advancement (Gil-Vernet). The first description of the advancement technique came from Glenn and Anderson [7], who described eight patients treated with a trigonal advancement technique. Intravesical mobilization is performed as for the Politano-Leadbetter, but from the original hiatus, a submucosal tunnel is created along the course of the trigone toward the bladder neck (Fig. 2). This advances the orifice, which is often laterally ectopic, into a more normal trigonal position. The length of the submucosal tunnel achievable was described as 1.5 cm.

The main advantage of this technique is its simplicity. It eliminates the need for extravesical dissection and neocystotomy. It positions the ureter just above the bladder neck, facilitating retrograde catheterization and instrumentation if required. There are limitations to this technique, however. The trigone and ureteral orifice location must have the correct configuration for this type of reimplantation to be successful. To ensure a proper submucosal tunnel length-to-ureteral diameter ratio, this technique should not be used for significantly dilated ureters because the tunnel length is limited [7,13].

Cross-trigonal (Cohen) reimplants also require initial intravesical mobilization of the ureter, but the ureter is reimplanted across the trigone toward the contralateral ureter. Cohen’s idea for this procedure came when he reimplanted two lower-pole ureters in a completely duplicated system, advancing them toward the midline to avoid mobilizing the nonrefluxing, normal, upper-pole ureters [9]. Although duplicated systems should be managed by common sheath reimplant with mobilization of both ureters, this experience inspired him to attempt to place the ureters in a cross-trigonal fashion [9,14]. The reimplantation of the ureters in this configuration creates a submucosal tunnel long enough to accommodate dilated ureters or tapered ureters (Fig. 3). Tunneling across the intact posterior bladder wall provides solid muscular backing [11,15–17].

This technique is a simple and reliable method for surgically correcting all grades of reflux. It is simpler to learn and perform than the Politano-Leadbetter reimplant, and therefore probably safer for less-experienced surgeons. The only disadvantage is the placement of the ureters out of their normal anatomic alignment, which may increase difficulty with retrograde catheterization of the ureter should it be required subsequently for treatment of urolithiasis. In the 25 years since the cross-trigonal technique was introduced, no
publications have supported the concern with difficult retrograde catheterization.

The midline advancement (Gil-Vernet) is a simple and rapid technique for the correction of VUR (Fig. 4). This technique is only suitable for ureters that are highly mobile intravesically. The mucosa between the ureteral orifices is incised in a transverse fashion. Mucosa is elevated off the detrusor muscle of the trigone in the bladder base. A nonabsorbable 3-0 nylon mattress suture, including Waldeyer’s sheath and the intrinsic musculature of the ureter, is placed and tied, bringing the ureters to the midline. Care should be taken not to perforate the ureter because the permanent suture would act as a foreign body and likely result in stone formation. The permanent suture is buried by approximating the mucosa over it. In Gil-Vernet’s original series he reported success in 36 of 38 (94%) patients [18].

Extravesical reimplantation

The extravesical ureteral reimplant was developed simultaneously and described by Lich and Gregoir [2,8]. The original description involved performing a midline cystotomy and placing

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**Fig. 1. Politano-Leadbetter ureteroneocystotomy.** The ureter is mobilized intravesically (Step 1). The submucosal tunnel is created and the neocystotomy is performed (Steps 2–3). The ureter is brought through the neocystotomy and the original hiatus is closed (Steps 4–6). The ureter is passed under the submucosal tunnel and the ureterovesical anastomosis is completed (Step 7). (Reproduced from Politano VA, Leadbetter WF. An operative technique for the correction of vesicoureteral reflux. J Urol 1958;79:932–41; with permission.)
ureter catheters. Following this, dissection of the ureters extravesically was performed to the region of the ureterovesical junction. The detrusor was incised laterally in a course along the natural path of the ureter, leaving the underlying mucosa intact. The trigonal attachments to the ureter were maintained. The detrusor is then sutured closed over the ureter, creating a longer submucosal tunnel. Modification of this technique in Europe involved making the detrusorotomy toward the dome of the bladder. In a large series of patients, this technique performed in a unilateral or a staged bilateral fashion had high success rates and low morbidity [19]. This technique initially was avoided in the United States following early reports of significantly higher failure rates versus intravesical ureteral reimplantation, but in the last two decades there has been a renewed interest [20–23]. Much of this enthusiasm followed the report of a modification of this technique that combines the extravesical reimplant with ureteral advancement, and is referred to as the detrusorrhaphy [20].

The detrusorrhaphy, like the original extravesical reimplant, involves dissecting the ureter down to the ureterovesical junction. The ureter is detached completely from the detrusor muscle fibers circumferentially, leaving only the mucosal attachments connecting the ureter to the bladder. As shown in Fig. 5, the ureter is attached only by the mucosa of the bladder and the detrusor incision is extended down toward the bladder neck to create space for advancement of the

Fig. 2. Glenn-Anderson ureteral reimplant. After mobilization of the ureter (Steps 1–3), a submucosal tunnel is created along the trigone toward the bladder neck (Step 4). The ureter is passed through the submucosal tunnel and reanastomosed to the bladder (Steps 5–6). (Reproduced from Glenn JF, Anderson EE. Distal tunnel ureteral reimplantation. J Urol 1967;97:623–6; with permission.)
The detrusor is incised posterior to the ureterovesical junction along the expected course of the ureter to create a sufficient length of the submucosal tunnel to prevent reflux. The length of this incision should depend on the grade of reflux and the diameter of the ureter. Vest-type sutures are placed into the ureteral musculature that advance and anchor the ureter to the apex of the detrusorotomy. The edges of the detrusor muscle are then approximated over the ureter to create the muscular backing of the submucosal tunnel. Both techniques have excellent results in terms of reflux resolution. The extravesical approach is amenable to reimplantation of single or duplicated ureters [23]. Paraureteral diverticuli can be repaired by the extravesical approach as well [24]. Transient hydronephrosis may develop in a small percentage of patients, but obstruction requiring reoperative reimplantation is extremely rare [49]. The most notorious complication of extravesical ureteral reimplantation is urinary retention when performed in a simultaneous, bilateral fashion. Table 1 compares the different intra- and extravesical techniques.

The risk for voiding difficulty following bilateral extravesical ureteral reimplantation is between 4% and 15% of patients [20–27]. Voiding difficulty is defined as urinary retention requiring intermittent or continuous catheterization beyond the normal postoperative time for catheter removal. This complication is one of the major deterrents preventing pediatric urologists from performing bilateral extravesical ureteral reimplantation.

Recently, an animal model has demonstrated a possible neurophysiologic basis for this complication [28]. The study was based on prior anatomic dissections of human cadavers demonstrating that the pelvic plexus is situated dorsomedial to the ureterovesical junction and extends toward the bladder neck [29]. Thus, dissection in the detrusor near the ureterovesical junction could injure the nerve fibers leading to the bladder. In a porcine model, unilateral mobilization of the ureter within 1 cm from the ureterovesical junction can produce unilateral loss of contractility of the bladder. Additionally, there was a greater than 50% decrease in the amount of pressure generated with stimulation of the motor nerves of the bladder [28].
In an effort to decrease the rate of postoperative voiding difficulty, a modified, inverted-Y dissection of the ureter, not dividing the muscle fibers attaching the ureter to the trigone completely, has been compared with the circumferential mobilization of the ureter [30]. In this study comparing 220 patients undergoing bilateral extravesical reimplant, the rate of urinary retention was 8.4% for the inverted-Y incision and 15.2% for the standard ureteral mobilization. These rates were not statistically different. As reported, the voiding dysfunction is temporary and the duration of intermittent or continuous catheterization is generally less than 2 weeks. Rarely, patients require intermittent catheterization for more than 1 month. No cases of permanent retention have been reported in patients undergoing extravesical ureteral reimplantation for primary VUR. Risk factors for urinary retention seem to be male gender, younger age (less than 2–3 years), and higher grades of reflux [26,30]. Patients with these characteristics should be followed carefully postoperatively; detailed preoperative counseling is needed to ensure parental understanding of this potential complication.

Success rates for extra- and intravesical ureteral reimplantation are similar. Rates are highest for grades I to III, with most series reporting rates of greater than 95% [9–11,13–23,31]. All techniques except Gil-Vernet still are used widely. No randomized studies have compared safety and efficacy among the choices of procedure. Experienced surgeons have reported excellent results with low complication rates. The rates are slightly lower with higher grades of reflux. No studies have shown conclusively one technique to be superior to another [1].

**Postoperative contralateral reflux: a continued problem**

A frustrating finding following an operation for unilateral reflux is de novo reflux of the contralateral ureter. Proposed etiologies for this problem include the correction of a low pressure pop-off valve (ie, the refluxing ureter that was repaired was masking the reflux by keeping the pressure in the bladder below that which would produce reflux in the contralateral side), trigonal distortion from the dissection of the reimplanted ureter (destabilization of the contralateral ureter allowing its intravesical tunnel length to decrease, resulting in reflux in a ureter that would not have previously), and failure to detect contralateral reflux preoperatively because of the intermittent nature of VUR [32–37]. Some reports indirectly support each of these theories, but none have been conclusive.

The rate of contralateral reflux is higher in patients with a history of resolved contralateral reflux. The incidence rates vary from 33% to 45% [38,39]. In one series, 100% of the de novo contralateral reflux resolved subsequently, but other series have reported only 20% resolution. Many surgeons consider it routine to reimplant a ureter that has refluxed previously because of this elevated rate of new-onset contralateral reflux [35,36,39]. Potential risk factors for the development of contralateral reflux, besides a history of prior reflux, include higher grades of reflux, duplicated system, fewer than two prior voiding cystourethograms, and voiding dysfunction [32,36]. Reported rates of resolution for new-onset contralateral reflux (excluding ureters with prior reflux) have ranged from 50% to 100%, with most showing rates near 50% at 1 to 3 years after diagnosis.

This suggests that a conservative initial approach is reasonable. Techniques previously used to predict who will develop contralateral reflux include observing the configuration and location of the orifice at the time of reimplantation and cystoscopy to evaluate for a laterally ectopic or gaping ureteral orifice. Neither has proved useful in predicting which patients will develop contralateral reflux [34,35,40]. In an attempt to diminish the rate of new-onset reflux following unilateral reimplant, unilateral Gil-Vernet reimplants of the nonrefluxing contralateral ureter have been performed [40,41]. Essentially, this is a prophylactic reimplant. The technique was chosen to minimize complications and the additional time to mobilize the ureter. Using this technique, the rate of new onset contralateral reflux is 0% to 6%, an improvement compared with 9% to 11% rate.
without the advancement in an age-matched control population in nonrandomized studies.

In one study of patients who underwent contralateral ureteral advancement and still developed reflux, all reflux resolved within 6 months, versus only 50% of those in the control group [40]. No complications were related directly to the advancement of the contralateral ureter. One must consider that a significant percentage of children will undergo an unnecessary procedure if this approach is adopted. The potential risks to which the ureter is exposed need to be weighed against the benefits in trying to prevent this relatively infrequent and often temporary complication.

Perioperative management

The management of the patient undergoing ureteral reimplantation has changed dramatically. Two-week hospital stays were reported commonly in early series [7]. Patients were managed routinely with a urethral or suprapubic catheter, ureteral stents, and surgical drain. The catheter and stents were left for several days and gradually removed. Currently, patients can be discharged routinely from the hospital on postoperative day 1 with no tubes in place [42]. Performing the procedure on an outpatient basis has been reported [43]. Earlier discharge from the hospital improves the use of hospital resources and has not resulted in unfavorable outcomes or increased risk to the patient. This approach is only relevant for uncomplicated ureteral reimplants for primary VUR.

Pain management has improved with the use of new medications such as ketorolac, which provides excellent relief of discomfort and bladder spasms. The use of local or regional blocks helps children recover quickly by providing better immediate postoperative pain relief [42,43]. Continuous epidural infusions have been used in patients with postoperative reimplantation with good pain control. A report concluded that an epidural catheter did not increase the length of stay (average length of stay 4 days for either group) [44]. If children are being discharged routinely 24 hours after surgery, however, an epidural left in likely would delay removal of the urethral catheter and increase the length of stay. A novel approach is the instillation of intravesical bupivacaine (0.25%, 0.05–0.1 mg/kg) into the bladder lumen before completion of the bladder closure [42]. In a series of patients treated using this technique, no urethral catheter was used.

The necessity of placement and timing of removal of bladder catheters has been investigated. Several investigators have concluded that a urethral catheter is not necessary after intravesical or extravesical ureteral reimplantation [42,43,45]. Certain patients undergoing bilateral extravesical ureteral reimplant (approximately 10%–15%) will not urinate spontaneously. Catheters can be placed in these patients postoperatively. In a series of 27 patients undergoing cross-trigonal ureteral reimplantation without a catheter, only 1 in 27 failed to void, and that patient had undergone reimplantation for bilateral duplex systems with excision of an ureterocele. It seems that earlier urethral catheter removal results in shorter hospital stays [46]. Postoperative stays of 24 to 48 hours with minimal or no catheter are possible without increase in morbidity. Detailed counseling and parental preparation are important in achieving the anticipated postoperative course. Investigators report that parental expectation and counseling were most important to early discharge from the hospital.

Ureteral stents and perivesical drains have been used routinely in children undergoing intravesical ureteral reimplantation. Multiple series have demonstrated that intravesical and extravesical reimplantations can be performed safely without ureteral stents [10,11,13,20–23]. There is no increased risk for hydronephrosis or obstruction in these patients [45,47]. The risk for anuria or acute renal failure in the case of bilateral ureteral reimplants is rare. One study has evaluated the characteristics of the drainage from the perivesical drain following intravesical reimplantation [48]. In 15 patients, the drainage on postoperative day 1 was consistent with serum in all. Multiple samples were evaluated before or after the urethral catheter was removed and urine was never detected. Of
urologists surveyed in this report, 63% of those performing extravasical, and 25% performing intravesical reimplants did not use a drain routinely. An additional 25% of those who used drains believed they were placed out of habit and unnecessary. At the authors’ institution, uncomplicated ureteral reimplants are managed routinely with a urethral catheter and without ureteral stents or perivesical drains. The urethral catheter is removed early in the morning of postoperative day 1, and most children are discharged later that day.

### Postoperative imaging studies

The typical radiographic evaluation of patients after ureteral reimplantation has been an upper-tract study to exclude obstruction and voiding cystouretrography to exclude persistent or new reflux. Initially, intravesical pyelograms were performed, but more recently, series report the use of renal ultrasound to detect hydronephrosis. When hydronephrosis is discovered and persists, either a diuretic renal scan or intravenous pyelogram is performed. Studies of intra- and extravasical reimplants have reported the development of mild, transient hydronephrosis in 6% to 7% of patients [49,50]. This typically resolved in nearly all patients. The overall rate of obstruction for ureteral reimplantation requiring surgical revision is less than 1% [1]. Upper-tract imaging studies are performed typically within 6 to 12 weeks of surgery. Earlier studies are indicated in patients with decreased urine output, elevated creatinine, hypertension, or with the development of flank pain [49].

Voiding cystourethrography is an invasive test that in some children can be traumatic. Efforts to decrease the traumatic nature of this procedure include using lubricants containing local anesthetic or conscious sedation [51,52]. Neither method eliminates fear and discomfort during the procedure. In some children, catheterizations are so traumatic that parents may choose surgical correction to limit the number of voiding cystourethograms the child must undergo while waiting for reflux to resolve [53]. The utility of postoperative voiding cystourethograms following intra- and extravasical reimplantation has been examined [49,54,55]. Success rates of 98% to 99% for cross-trigonal reimplantations have been reported. Most children will have to undergo a negative test to detect the few who have persistent reflux. Furthermore, there is no evidence that altering the management of persistent postoperative reflux is of significant benefit to the patient.
In recent years, many pediatric urologists have adopted a practice of not performing postoperative voiding cystourethrograms routinely in patients undergoing uncomplicated ureteral reimplantation for primary VUR. Before adopting such a policy, one may want to ensure that one's surgical outcomes meet the standards published (at least a 95% success rate). The second important component to this policy is parental education and discussion. In the case of bilateral reimplants, there is low risk for postoperative reflux, but with a unilateral reimplant, the risk is significantly greater because of the onset of new contralateral reflux.

One needs to decide whether the findings of the voiding cystourethrogram would alter one's management. If antibiotics prophylaxis would be continued for persistent reflux, then postoperative voiding cystourethrograms should be performed [55]. If the surgeon's policy would be to stop prophylaxis and observe the patient expectantly, however, then omitting the voiding cystourethrogram would be reasonable. Parents and the surgeon need to agree on a comfortable level of risk when making this decision. In the case of extravesical reimplants, there is a high (95%) cure rate. The overall cure rate is higher with reflux grade III or less versus grades IV and V (99% versus 94%); thus, it has been recommended that routine cystography is necessary only for high-grade reflux (IV and V) [49]. Limiting the use of postoperative ultrasound to patients who are symptomatic or who have risk factors for developing hydronephrosis, such as dysfunctional voiding, preoperative hydronephrosis, flank pain, hypertension, or an elevated creatinine, has been proposed [50]. Nonetheless, the routine use of ultrasound seems more justified because it is non-invasive and painless and can detect a potential silent obstruction and prevent the delayed complication of significant injury to the kidney by providing early diagnosis.

**Minimally invasive treatment of vesicoureteral reflux**

**Laparoscopic repair**

Laparoscopic ureteral reimplant is a technically challenging procedure. Two distinct techniques for the intravesical repair of vesicoureteral reflux have been reported. The first reports in children were performed by medial advancement (Gil-Vernet technique) of the ureters [56]. The procedure was changed later because of high failure rates (greater than 50%) than a cross-trigonal (Cohen) technique. These techniques have not resulted in success rates comparable to the open surgery (80% with the intravesical cross-trigonal technique) [57,58].

Laparoscopic extravesical ureteral reimplantation was first reported in 1993 in an animal model [59]. A consecutive series of 47 patients and 71 ureters reimplanted since 1997 reports 100% success [60]. During the early development of this technique, ureteral injury occurred in three patients, requiring surgical revision in two. Preliminary reports have demonstrated that after bilateral laparoscopic extravesical reimplantation, there is no significant instance of voiding dysfunction compared with expected rates with open bilateral extravesical reimplant [61]. Although these techniques are not practiced widely, the last decade has seen a dramatic change in the practice of laparoscopic surgery in urology. Adult procedures once considered unsuitable for laparoscopy are now reported in large series with comparable operative times. With future improvements in instrumentation and possible use of robotic assistance, this procedure may become a more viable alternative to open surgery, especially in older children and adolescents. Because of the relatively small size of the pelvis in younger children, its role in these patients likely will be limited.

**Endoscopic correction of vesicoureteral reflux**

Endoscopic treatment of reflux has been practiced for the past two decades. The American Urologic Association guidelines for the treatment of VUR did not recommend endoscopic injection for the treatment of reflux because of a lack of data documenting the efficacy of this treatment and the lack of a suitable and safe implant material. The first material used was polytetrafluoroethylene, a paste of Teflon particles. Subureteric Teflon injection procedure has been used more extensively in Europe. A large multi-center series of over 8000 patients has been reported [62].

Other implants that have been used include bovine cross-linked collagen, autologous chondrocytes, dextranomer/hyaluronic acid copolymer, polydimethylsiloxane, and other substances [63]. Of the implants listed, only dextranomer/hyaluronic acid copolymer is available in the United States and approved by the FDA for use in the endoscopic correction of primary VUR, grades II to IV, in patients with single collecting systems [3]. Polytetrafluoroethylene has been favored in
Europe because of its high success rate. Polytetrafluoroethylene particles are a nonbiodegradable permanent implant. The major concern with polytetrafluoroethylene is that the particles are small enough to migrate in lymphatic channels and capillaries. Documentation demonstrates the migration of particles following injection in the urinary tract [64]. Because of safety concerns it is no longer used in the United States, but large series do not report complications related to the Teflon paste [62].

Autologous chondrocytes are a biocompatible material, circumventing the concerns about long-term problems with implants containing Teflon or silicone-based implants. The procedure involves an excisional biopsy to obtain the chondrocytes, which are expanded in vitro and suspended in an alginate solution that is injected subureterically [65]. Viable chondrocytes have not been demonstrated in patients who failed endoscopic therapy and underwent ureteral reimplantation. Whether this represents the cause of the treatment failure or the inability of the chondrocytes to survive after injection is unknown.

Glutaraldehyde cross-linked bovine collagen was developed and used widely as an injectable material for the treatment of incontinence. When injected subureterically it had a reasonable early success rate, but long-term studies have shown unacceptably high failure rates over time [66]. It is biodegradable and, because of the potential for an immune reaction against the collagen protein, patients need to undergo skin testing before implantation. Dextranomer/hyaluronic acid copolymer has been studied primarily in Europe, where it was used first. It has results that are comparable to Teflon, but the dextranomer particle size is larger, which should prevent migration [67,68]. Polydimethylsiloxane is a solid silicone elastomer suspended in a polyvinylpyrrolidone hydrogel. The hydrogel is removed by the reticuloendothelial system and excreted [69].

The technique of endoscopic injection for VUR begins with cystoscopic examination of the orifice. The use of a cystoscope with an offset lens and a straight 4–5 French working channel is important because the needle can be bent easily when passing through the offset channel of standard cystoscopes, making it difficult to position [3]. The needle is inserted a few millimeters distal and medial to the orifice, and advanced into position just under the ureter. Injection should produce a mound of implant material that elevates the ureteral orifice and causes it to assume a crescent shape. The amount injected varies with implant types. Mean volumes of 0.6 to 0.8 mL reported for dextranomer/hyaluronic acid copolymer and 0.4 mL for polytetrafluoroethylene [3,67,70]. After the injection is complete, the needle is left in place for 15 to 30 seconds before withdrawing it. The site

<table>
<thead>
<tr>
<th>Implant</th>
<th>% Reflux cured with one injection</th>
<th>Biodegradable</th>
<th>Comments</th>
</tr>
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<tbody>
<tr>
<td>Autologous chondrocytes</td>
<td>55%</td>
<td>Autologous</td>
<td>Requires two procedures: cartilage harvest and the subsequent subureteric injection</td>
</tr>
<tr>
<td>Bovine cross-linked collagen</td>
<td>72%</td>
<td>Yes</td>
<td>Skin allergy testing prior to treatment; high relapse rate after 1 y</td>
</tr>
<tr>
<td>Dextranomer/hyaluronic acid copolymer</td>
<td>72%</td>
<td>Yes</td>
<td>Nonimmunogenic; easy to inject with syringe and needle; only implant FDA-approved for the treatment of reflux in children in the United States</td>
</tr>
<tr>
<td>Polydimethylsiloxane</td>
<td>82%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>No</td>
<td>Solid silicone elastomer soft tissue bulking agent suspended in bioexcretable carrier gel</td>
</tr>
<tr>
<td>Polytetrafluoroethylene</td>
<td>73%</td>
<td>No</td>
<td>Teflon particles suspended in glycerine; small particle size makes migration a concern; most studied of all implants with largest series</td>
</tr>
</tbody>
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<sup>a</sup> Overall for all reflux grades.
<sup>b</sup> Grades I–III only.
should be inspected to ensure that the implant does not extrude and the orifice has maintained its position at the top of the mound.

Table 2 shows the agents used for implantation and reported success rates for a single injection. Success rates, as with surgical reimplantation, are higher for lower grades of reflux. Success rates varied from 98% to 83% for grades I to V reflux when treated with polytetrafluoroethylene using repeat injections for failures [62,70]. Polymethylsiloxane and dextranomer/hyaluronic acid copolymer have similar reported rates of success rates varying from 90% to 65% for reflux grades I to V [3,67,69,71]. The long-term efficacy of preventing reflux is not well established with these agents. For the dextranomer/hyaluronic acid copolymer, most studies only performed cystograms at 3 months or 1 year from the procedure [3,67]. In studies of collagen, the high failure rate did not occur until years later [66]. For the dextranomer/hyaluronic acid copolymer, there is one long-term study with 228 patients at a median follow-up of 5 years. The overall success rate (defined as no reflux or grade I reflux) was 68% [67]. Most patients had undergone their latest cystogram 12 months postoperatively. There were 334 ureters treated, of which 45 ureters without reflux underwent a late voiding cystourethrogram at a median of 3 years postinjection, showing a recurrent reflux rate of 13%. The implant is biodegradable, but length of time for resorption is not known.

A question remains about whether patients, especially girls, may have problems with recurrent reflux in adulthood, particularly during their reproductive years. Unfortunately, no data are available regarding the efficacy of endoscopic treatment of reflux in children as they grow into adulthood. The risk of obstruction is low with endoscopic injection. Ultrasound studies have failed to show a significant rate of hydronephrosis, even when checked at postoperative day 1 [67]. Children are treated as outpatients and have little to no discomfort [3]. The typical follow-up protocol for patients is similar to that of open surgical reimplantation, with an ultrasound and cystogram performed 6 to 12 weeks following the procedure.

Summary

Surgical reimplantation remains a highly effective and safe technique for the correction of VUR. Endoscopic correction of VUR is an option as an alternative to surgical reimplantation. The morbidity and recovery from endoscopic correction of reflux is improved versus reimplantation, but is less efficacious and the long-term results into adulthood are unknown.

References


