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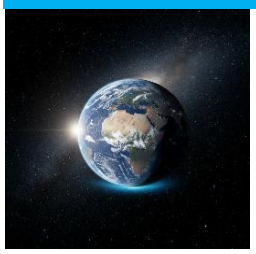

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Surgical Management of Vesicoureteral Reflux and Ureteral Strictures in Atypical Ureteral Anatomy: A Narrative Review

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Abstract

Introduction and Objective: Congenital anomalies of the ureter affect 1% of the population and can lead to complications like vesicoureteral reflux (VUR) and ureteral strictures (US). This review aims to summarize current surgical treatments for these conditions, focusing specifically on patients with atypical anatomy, such as ectopic, retrocaval, or duplex ureters.

Review Methods: A literature review of PubMed and Scopus databases was conducted, in accordance with the PRISMA guidelines, focusing on English-language papers published within the last five years. Evaluated surgical approaches included open, endoscopic, laparoscopic, and robotic methods. Following the application of specific inclusion and exclusion criteria, a total of 33 articles were selected for qualitative synthesis. Due to the early diagnosis of these anomalies, the analyzed data primarily concerns pediatric patients.

Results: Open surgery remains the gold standard for severe VUR, but minimally invasive laparoscopic and robotic options are gaining popularity. For complex congenital anomalies, treatments must be highly customized. Functioning ectopic ureters require reimplantation, while poorly functioning ones are managed with laparoscopic clipping. Retrocaval ureters or duplex systems benefit from advanced robotic repairs. Obstructive megaureters and ureteroceles are initially treated with less invasive endoscopic methods (balloon dilation or incision) to relieve pressure.

Summary: The management of VUR and US in patients with complex anatomy lacks a single standard approach, requiring individualization based on specific anatomy and kidney function. While open surgery is effective, urology is shifting toward minimally invasive techniques to

lower risks. There is a notable lack of comprehensive literature regarding surgical outcomes in adults and complex congenital presentations.

Keywords: Vesico-Ureteral Reflux, Ureteral Obstruction, Urogenital Abnormalities, Urologic Surgical Procedures, Minimally Invasive Surgical Procedures

Introduction and Objective

The aim of this article is to summarize the current knowledge and identify limitations in existing literature on surgical treatment techniques for vesicoureteral reflux (VUR) and ureteral strictures (US), focusing specifically on the choice of surgical treatment in patients with atypical anatomical variants of the ureters.

Congenital anomalies of the ureter are relatively common, affecting up to 1% of individuals [1]. Although congenital anomalies of the upper urinary tract may be asymptomatic some individuals experience complications (eg, related to upper urinary tract obstruction, stone formation, infection, hypertension, or renal failure) [2].

Functional disorders of atypical ureters arise both as a result of the anatomical abnormality itself and from other causes. Ureter obstruction and vesicoureteral reflux are often observed in patients with atypical anatomical features of ureters and may require surgical treatment.

Most of the studies on anatomical abnormalities of ureters and primary VUR refer to pediatric patients. Thus this review contains mostly data associated with children.

1. Literature Review Methods

A comprehensive literature review was conducted utilizing the PubMed and Scopus databases. The methodology and reporting of this review were guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.The search strategy was restricted to English-language scientific papers published within the last five years. To identify relevant studies, a combination of MeSH terms and non-MeSH keywords was employed, including “Ureter”, “Vesicoureteral Reflux”, “Ureter Constriction”, “Ureterocele”, “Retrocaval Ureter”, “Ectopic Ureter”, “Duplex Ureter”, “Ureter Stricture”, “Surgery”, “Endoscopy”, “Injection”, and “Laparoscopy”. The inclusion criteria encompassed case reports, single-center studies, review articles, and meta-analyses. Articles were strictly excluded from the review if the full text was unavailable. Following the application of these criteria, a total of 33 articles

were assessed and included in the final qualitative synthesis. Furthermore, a formal assessment of the risk of bias among the included studies was not performed. This approach was chosen because the primary intent of this article is to provide a broad synthesis of current knowledge to guide management decisions , rather than to conduct a strict systematic review or formal meta-analysis

2. Results

3.1. Surgical Approaches of VUR and US in Patients with Intact Ureteral Anatomy

3.1.1. Vesicoureteral reflux

Vesicoureteral reflux (VUR) is characterized by the abnormal backward flow of urine from the urinary bladder into the upper urinary tract during voiding [3]. Primary VUR is an anatomical and/or functional/physiological disorder with potentially serious consequences, such as focal uptake defects on a radionuclide scan, hypertension, and renal failure [4]. Estimated prevalence rates for primary VUR range between 0.4 and 1.8% [4,5]. Secondary VUR is caused by bladder outlet obstruction or neurogenic bladder dysfunction and it may lead to the same complications as primary VUR [4].

VUR needs to be studied and staged to identify the best therapeutic option [6]. The severity of VUR is described by a grading system according to the findings of a voiding cystourethrogram (VCUG), with grades ranging from I (mild) to V (severe) [5].

Management may be non-surgical (e.g., urotherapy, antibiotic therapy), minimally invasive (endoscopic injection) or surgical (ureteral reimplantation) [5]. The choice of therapy varies depending on factors such as clinical presentation, patient age, VUR grade, kidney function, UTI frequency, and renal growth patterns [3].

There is limited reporting on the surgical outcomes of adult patients with VUR because most patients receive treatment during childhood or the reflux spontaneously resolves in several cases. According to current studies, 68 % of surgically treated reflux cases are currently being treated by open reimplant, only 25% by endoscopic injection (EI) and 6% minimally invasive reimplant [3]. Laparoscopic extravesical ureteral reimplantation (LEVUR) and robot-assisted laparoscopic ureteral reimplantation (RALUR) are alternatives to open approach [8].

3.1.1.1. Open reimplantation

Multiple studies published in recent years continue to consider open surgery as the reference surgical treatment for VUR with good long-term outcome and success rates up to 90% [9]. It is accepted as the gold standard in the treatment of children with primary high grade VUR [10].
Patients are now individually risk-stratified taking into account multiple factors as well as parental preferences. High risk VUR as well as symptomatic high grade VUR (grades IV and V) is an indication for surgical management with open ureteral reimplantation (OUR) [10].
The operations consist of lengthening the intramural ureter with a submucosal tunnel. In intravesical procedures like Cohen and Politano–Leadbetter the anterior bladder wall is accessed via a suprapubic Pfannstiel incision with transverse skin incision and longitudinal opening of the fascia extraperitoneally. Then, the anterior bladder wall is longitudinally opened [11]. In these techniques submucosal tunnel is created intravesically. They enable bilateral reimplantation. In extravesical Lich-Gregoir procedure a submucosal tunnel is created from the outside of bladder lumen. This method is not preferred for bilateral procedures due to the risk of transient bladder dysfunction. However, it is technically demanding, does not require opening the bladder and guarantees shorter hospital stays [12].
Ureteral reimplantation offers multiple benefits, including low complication rates and excellent success rates (SR) (92–98%) [13]. In addition, Shadpour et al claim that through open surgery 91.2 % of patients gained absolute radiological resolution (ARR) of reflux [14]. Nonetheless, open procedures require a sufficiently large skin incision and (intravesical ones) opening of the bladder to reach the surgical site. This leads to increased postoperative wound pain, slight postoperative bleeding into the bladder, possible bladder spasms and micturition difficulties [11]. Thus, longer recovery time.

3.1.1.2. Minimally Invasive Reimplantation

Minimally invasive reimplantation techniques include laparoscopic (LUR) and robotic (RALUR) methods. With the recent progress in minimally invasive surgery (MIS), laparoscopic and robot-assisted methods are gaining popularity [15].

Both laparoscopic and robotic-assisted methods can utilize extravesical and vesicoscopic reimplantation. Extravesical reimplantation is often the preferred and most frequently used technique in robotic-assisted surgery (e.g., RALUR-EV - Robot-Assisted Laparoscopic Extravesical Ureteral Reimplantation).Intravesical Reimplantation (Vesicoscopic) requires insufflating (filling) the bladder with gas (pneumovesicum) to create a working space. It is technically feasible but is generally considered more complex than the extravesical approach in the robotic setting.

During the last decade, series of conventional LUR have shown good results and few complications, even in cases of complex anatomy [9]. RALUR had a longer operative time and lower SR than LUR with comparable complication rates. The overall SR of both procedures is higher in the paediatric patients than in the adult group. Among paediatric patients, the overall SR and complication rate were not significantly different between the procedures. Both LUR and RALUR are favourable and safe procedures for paediatric patients with primary VUR [15]. Available evidence shows that in adults RALUR offers similar surgical outcomes if compared to OUR, and potential advantages in terms of lower estimated blood loss, shorter hospital length of stay, catheter, and stent time [16].

3.1.1.3. Endoscopic injection

EI is a procedure based on suburethral injection of bulking agents under cystoscopic guidance [17]. It is currently the first-line therapy for children with grade III–V primary reflux in many institutions worldwide [8].

Most authors offer this treatment option to patients with breakthrough febrile UTIs, or febrile UTIs after discontinuation of continuous antibiotic prophylaxis (CAP), or first febrile UTI in toilet trained patients, or poor parental compliance to CAP [8].

Regarding the technique of injection, there are 3 major procedures: subureteric injection (STING), Hydrodistention Implantation Technique (HIT) and double HIT. The latter is currently the most performed technique of endoscopic correction of VUR in the United States [8].

The benefits of this procedure include low invasiveness and morbidity [18]. However, high grade reflux and bilaterality predicts lower absolute radiological resolution in endoscopic surgery [14]. Moreover, EI has been reported to be effective with the first treatment in grade 4 and 5 VUR in 63 and 51% [17] which is less than other surgical options.

3.1.2. Ureteral Strictures

The ureteral stricture is a fixed narrowing of the ureter, leading to a urodynamically relevant urinary transport disorder and consecutive hydronephrosis of the affected kidney [19]. Common causes of ureteral stenosis are repeated inflammation, surgical scar, injury, congenital development factors, ureteral tumor or tumor compression [20]. The primary goal of treating benign ureteral strictures aims to restore durable patency of the urinary collection system and preserve renal function [21]. The latest literature focuses mainly on robotic operations for ureteral strictures, and there are few new articles on other treatment methods.

Planning treatment for ureteral strictures requires a detailed assessment of stricture and patient characteristics. Given the various treatment options, various methods must be considered for each patient [22]. Strictures < 2 cm are amenable for endoscopic (minimally invasive) treatment however, often, endoscopic treatment fails for strictures longer than > 2 cm [23]. Short-segment proximal strictures and strictures at the pyeloureteral junction are typically surgically managed with Anderson-Hynes pyeloplasty. End-to-end anastomosis (ureteroureterostomy) can be performed for short-segment proximal and middle ureteral strictures. Distal strictures are treated with ureteroneocystostomy and are often combined with a Boari and/or Psoas Hitch flap [22]. Ileal Ureter Replacement can be performed in very long strictures where local tissue cannot be used, or in cases of multiple prior failed reconstructions. The autotransplantation method requires a sufficient length of healthy ureter to allow tension-free ureterovesical anastomosis [24]. Nephrectomy is considered only if the kidney has minimal function and repair is impossible.

Table 1

Condition and Approach	Technique / Method	Key Characteristics & Outcomes
VUR: Open Reimplantation	Intravesical (Cohen, Politano-Leadbetter)	• Reference method for primary high-grade VUR. • Enables bilateral reimplantation.
VUR: Open Reimplantation	Extravesical (Lich-Gregoir)	• Shorter hospital stays. • Not preferred for bilateral procedures.

VUR: Minimally Invasive	Laparoscopic (LUR) & Robotic (RALUR)	• Safe for pediatric patients. • Offers adults lower blood loss and shorter stays.
VUR: Endoscopic Injection	STING, HIT, double HIT	• First-line pediatric therapy for grades III–V. • Low invasiveness. • Lower success rates for high-grade or bilateral reflux.
US: Endoscopic Treatment	Minimally invasive procedures	• Suitable for strictures < 2 cm.
US: Surgical Reconstructions	Anderson-Hynes pyeloplasty and Ureteroureterostomy	• Anderson-Hynes: for proximal/junction strictures. • Ureteroureterostomy: for short proximal/middle strictures.
US: Advanced Reconstructions	Ureteroneocystostomy, Ileal Replacement, Autotransplantation	• Ureteroneocystostomy: for distal strictures. • Ileal Replacement/Autotransplantation: for very long or previously failed strictures.

Summary of the surgical approaches of VUR and US in patients with intact ureteral anatomy.

3.2. Surgical Approaches of VUR and US in Patients with anatomical anomalies of ureter (Table 2)

3.2.1. Ectopic ureter

The surgical management of ectopic ureters complicated by strictures and vesicoureteral reflux (VUR) relies on an individualized approach determined by anatomical configuration and functional status of the affected renal moiety [25]. Recent studies show that when the ectopic ureter is associated with a functioning kidney, the primary surgical goal is to preserve renal function alongside the resolution of urinary leakage and reflux. It is frequently achieved through personalized reconstructive techniques such as ureteral reimplantation [25]. In contrast, ectopic ureters often drain poorly functioning or entirely non-functioning dysplastic renal segments, particularly in duplex systems. While the traditional management for these non-functioning units heavily relied on procedures such as heminephrectomy or ureteroureterostomy, current evidence supports the adoption of less morbid, minimally invasive alternatives [26]. Notably, laparoscopic ureteral ligation (clipping) has emerged as a safe and effective surgical option for

these patients. By isolating and clipping the ectopic ureter, surgeons can successfully resolve the associated clinical burdens including continuous incontinence and the recurrent infections exacerbated by VUR or distal strictures while avoiding the perioperative risks of anastomotic strictures, bleeding, or the inadvertent devascularization of the healthy renal moiety that accompany traditional open surgeries [27].

3.2.2. Retrocaval Ureter

The surgical management of ureteral strictures and obstruction, secondary to retrocaval ureters, relies heavily on operative intervention to preserve renal function and resolve chronic symptoms [28]. The literature focuses on upper tract ureteral strictures rather than VUR. It establishes that the definitive treatment for symptomatic obstruction typically involves the mobilization and excision of the stenotic or retrocaval segment, followed by the tension-free re-establishment of urinary tract continuity [28]. Minimally invasive techniques, including transperitoneal laparoscopic and robot-assisted approaches, have emerged as safe and feasible standards of care that are associated with minimal morbidity and excellent operative visualization [29,30]. Procedures such as dismembered laparoscopic ureteropyeloplasty or robot-assisted ureteroureterostomy are routinely performed over a JJ stent, giving favorable clinical outcomes, improved renal function, and high success rates without the necessity of open conversion [29,30].

3.2.3. Megaureter and Ureterocele

For primary obstructive megaureters presenting with persistent dilation or stricture, traditional open ureteral anti-reflux reimplantation often requiring ureteral tapering, plication, or remodeling has historically been the standard of care [31]. However, high-pressure endoscopic balloon dilation is increasingly favored as a safe, first-line alternative that offers definitive treatment with reduced morbidity, quicker recovery, and shorter hospital stays [31,32]. When megaureters are primarily refluxing, the surgical goal is to establish an effective anti-reflux valve mechanism through an adequate submucosal tunnel without introducing secondary post-surgical strictures; this is now frequently accomplished using advanced laparoscopic and robotic-assisted extravesical or transvesicoscopic reimplantation technique [32]. In cases complicated by a ureterocele that causes upper urinary tract obstruction, urgent endoscopic incision or puncture is the recommended initial procedure to rapidly decompress the collecting

system [33]. While endoscopic decompression is highly effective initially, definitive reconstructive surgery or secondary ureteral reimplantation may still be necessary depending on the subsequent development of iatrogenic VUR, persistent distal strictures, or the overall functional status of the affected renal moiety [32,33].

3.2.4. Duplex ureter

The surgical management of VUR and US in patients with a duplex collecting system presents unique anatomical challenges that require tailored, patient-specific approaches [1,2]. For VUR in a duplex ureter, while endoscopic injection of bulking agents serves as a minimally invasive option, definitive management often necessitates ureteral reimplantation [8,18]. Techniques such as the laparoscopic or open extravesical Lich-Gregoir reimplantation have proven highly effective for duplex anomalies, successfully resolving reflux while minimizing surgical morbidity [12]. Furthermore, in specific cases where an ectopic ureter is associated with a non-functioning renal moiety, simplified approaches like targeted ureteral clipping can safely manage persistent symptoms such as urinary dribbling [27]. Conversely, addressing benign ureteral strictures within a duplicated system increasingly relies on advanced reconstructive techniques [19,21]. Depending on the stricture's location, length, and severity, robotic-assisted repairs and laparoscopic ureteroplasty sometimes utilizing oral mucosal grafts provide excellent functional outcomes while safely navigating the complex vascular anatomy inherent to duplex systems [20,23].

Table 2

Anatomical Anomaly	Surgical Approach / Technique	Key Characteristics and Outcomes
Ectopic Ureter	Ureteral reimplantation	• Used for functioning kidneys . • The goal is to preserve renal function while stopping urinary leakage and reflux.
Ectopic Ureter	Laparoscopic ureteral ligation (clipping)	• Used for poorly functioning/non-functioning segments. • Resolves incontinence and infections. • Avoids risks of traditional open surgery.
Retrocaval Ureter	Mobilization and excision	• Involves excising the stenotic segment. • Re-establishes a tension-free urinary tract.

Retrocaval Ureter	Laparoscopic ureteropyeloplasty / Robotic ureteroureterostomy	• Safe, standard of care using a JJ stent . • High success rates and improved renal function without open conversion.
Megaureter	Endoscopic balloon dilation	• First-line alternative for obstructive megaureters . • Reduced morbidity and quicker recovery.
Megaureter	Laparoscopic/ Robotic reimplantation	• Used for refluxing megaureters . • Establishes an anti-reflux valve without causing new strictures.
Ureterocele	Urgent endoscopic incision/puncture	• Initial procedure to rapidly decompress an obstructed system . • Definitive reconstructive surgery may still be needed later.
Duplex Ureter	Lich-Gregoir reimplantation	• Highly effective for resolving VUR . • Minimizes surgical morbidity.
Duplex Ureter	Robotic-assisted repairs and Laparoscopic ureteroplasty	• Used for benign strictures . • Safely navigates complex duplex vascular anatomy for excellent outcomes.

Summary of the surgical approaches of VUR and US in patients with anatomical anomalies of ureter.

4.Discussion

The surgical management of vesicoureteral reflux (VUR) and ureteral strictures (US) in patients presenting with complex congenital anomalies lacks a single standardized approach, necessitating highly customized treatments based on specific anatomy and renal function. While open ureteral reimplantation remains the established gold standard for high-grade and complex presentations, current trends indicate a definitive shift toward minimally invasive techniques. Advancements in laparoscopic and robot-assisted surgeries offer safe, effective alternatives that significantly lower surgical morbidity. For instance, retrocaval ureters or duplex systems show excellent functional outcomes with advanced robotic repairs, while poorly

functioning ectopic ureters are effectively managed with laparoscopic clipping. Endoscopic interventions also continue to serve as a valuable first-line therapy for specific patient profiles.

A major limitation in evaluating these surgical outcomes is the nature of the available evidence. Due to the rarity of these specific anatomical anomalies, the current literature relies heavily on retrospective studies and case reports, which precludes the execution of a formal meta-analysis. Additionally, because these congenital anomalies are typically diagnosed early in life, the evaluated data primarily concerns pediatric patients. Consequently, there is a notable lack of comprehensive, high-quality literature regarding long-term surgical outcomes in adult populations with complex congenital presentations.

5. Conclusion

The treatment of VUR and US in the presence of anatomical anomalies requires a highly individualized strategy tailored to the patient's specific anatomical variant, functional renal status, and age. Although open surgery remains highly effective, urological management is shifting toward the continued adoption of minimally invasive and endoscopic techniques to lower surgical risks. Future high-quality research must focus on addressing the significant gap in literature concerning adult populations.

6. Disclosure:

All authors have read and approved the final version of the manuscript for publication

7. Author Contributions:

Monika Kamińska: Conceptualization, Methodology, Writing Original Draft, Bartosz Niemiec: Investigation, Data Curation, Formal Analysis Zuzanna Drozd: Resources, Validation, Writing Review and Editing, Bruno Olesiński: Visualization, Writing Original Draft, Szymon Piosik: Validation, Data Curation, Writing Review and Editing, Natalia Dudziak: Investigation, Validation, Writing Original Draft; Łukasz Piasecki: Writing Original Draft, Zuzanna Guzowicz Methodology, Writing Original Draft. Patrycja Gągałka: Resources, Writing Review and Editing.

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Not applicable.This review did not involve human participants. The study was based solely on the analysis of previously published scientific literature and data, and therefore did not require informed consent from any individuals.

10. Informed Consent Statement:

All data used in this systematic review are entirely contained within the published article and/or are available in the public domain through the cited scientific literature and databases (e.g., PubMed, Google Scholar). The authors confirm that the data supporting the findings of this study are available within the article.

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Conflicts of Interest:

The authors declare no conflict of interest.

In preparing this work, the authors used Gemini by Google for the purpose of improving language clarity, enhancing readability, and organizing scientific content. After using this tool, the authors have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

12..List of abbreviations

ARR: Absolute radiological resolution
CAP: Continuous antibiotic prophylaxis
EI: Endoscopic injection
HIT: Hydrodistention Implantation Technique
LEVUR: Laparoscopic extravesical ureteral reimplantation
LUR: Laparoscopic ureteral reimplantation
MIS: Minimally invasive surgery
OUR: Open ureteral reimplantation
RALUR: Robot-assisted laparoscopic ureteral reimplantation
RALUR-EV: Robot-assisted laparoscopic extravesical ureteral reimplantation
SR: Success rates

STING: Subureteric injection

US: Ureteral strictures

UTI: Urinary tract infection

VCUG: Voiding cystourethrogram

VUR: Vesicoureteral reflux

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