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Surgical Interventions for Pediatric Vesicoureteral Reflux: Outcomes and Key Predictors of Success

Pediatrik Vezikoüreteral Reflüde Cerrahi Girişimler: Sonuçlar ve Başarıyı Belirleyen Temel Etkenler

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Abstract: Vesicoureteral reflux (VUR) is the most common urinary system disorder in children and can lead to chronic kidney failure. This study aims to evaluate the effectiveness of endoscopic and surgical treatments for VUR in pediatric patients. We retrospectively reviewed data from children who underwent surgical treatment for VUR between January 2010 and December 2019 at Sami Ulus Obstetrics and Gynecology, Pediatrics, Health Practice, and Research Center. A total of 157 patients (113 girls, 44 boys) were included. The success rate of the first STING was 31.8% for 0–6 years, 43.9% for 6–12 years, and 75% for 12–18 years. Success was 46% for low/moderate reflux and 24.5% for high-grade reflux. Overall, the first STING success rate was 38.6%, increasing to 59.5% with multiple injections. Females had a higher history of preoperative UTIs (p = 0.006) and a higher rate of low-grade reflux (p = 0.023). The success rate was significantly higher in the 12-18 years group (p = 0.032) and lower in high-grade reflux (p = 0.015). Girls had a significantly higher rate of postoperative UTIs (p = 0.0001). Surgical success in pediatric VUR is influenced by age and reflux grade, with better outcomes in older children and those with low/moderate reflux. Given the lower efficacy of STING in high-grade VUR, open surgery may be a preferable option in these cases. Higher postoperative UTI rates in girls suggest a need for closer follow-up and potential prophylaxis adjustments. Tailored treatment based on individual risk factors may improve outcomes.
Keywords: Child, Ureter, Vesicoureteral reflux, Ureteral reimplantation, Endoscopic surgery

Özet: Vesikoüreteral reflü (VUR), çocuklarda en yaygın üriner sistem anomalisidir ve kronik böbrek yetmezliğine yol açabilir. Bu çalışma, pediatrik hastalarda VUR için endoskopik ve cerrahi tedavilerin etkinliğini değerlendirmeyi amaçlamaktadır. Ocak 2010 ile Aralık 2019 tarihleri arasında Sami Ulus Kadın Doğum ve Çocuk Hastalıkları, Sağlık Uygulama ve Araştırma Merkezi'nde VUR için cerrahi tedavi uygulanan çocukların verileri retrospektif olarak incelenmiştir. Toplamda 157 hasta (113 kız, 44 erkek) dahil edilmiştir. İlk STING tedavisinin başarı oranı, 0–6 yaş için %31,8, 6–12 yaş için %43,9, 12–18 yaş için ise %75 olarak bulunmuştur. Başarı oranı, düşük/orta dereceli reflüde %46, yüksek dereceli reflüde ise %24,5 olarak kaydedilmiştir. Genel olarak, ilk STING başarı oranı %38,6 olup, birden fazla enjeksiyonla bu oran %59,5'e çıkmıştır. Kız çocukları, preoperatif idrar yolu enfeksiyonları (İYE) açısından daha yüksek bir geçmişe sahipti (p = 0,006) ve düşük dereceli reflü oranları daha yüksekti (p = 0,023). Başarı oranı, 12-18 yaş grubunda anlamlı derecede daha yüksekti (p = 0,032) ve yüksek dereceli reflüde ise daha düşüktü (p = 0,015). Kız çocuklarında postoperatif idrar yolu enfeksiyonları oranı anlamlı derecede yüksekti (p = 0,0001). Pediatrik VUR'da cerrahi başarısı yaş ve reflü derecesinden etkilenmektedir; daha iyi sonuçlar, daha büyük çocuklarda ve düşük/orta dereceli reflüsü olanlarda gözlenmektedir. Yüksek dereceli VUR'da STING yönteminin etkinliğinin düşük olması, bu olgularda açık cerrahinin daha uygun bir seçenek olabileceğini düşündürmektedir. Kız çocuklarında daha yüksek postoperatif İYE oranları, daha yakın izlem ve profilaksi düzenlemesinin gerekebileceğini göstermektedir. Bireysel risk faktörlerine göre uyarlanmış tedavi, sonuçları iyileştirebilir.
Anahtar Kelimeler: Çocuk, Üreter, Vesikoüreteral reflü,Üreteral reimplantasyon, Endoskopik Cerrahi

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1. Introduction

Vesicoureteral reflux (VUR) is among the most common congenital anomalies of the urinary tract in children, frequently diagnosed following febrile urinary tract infections (UTIs). It results from an abnormal ureterovesical junction that permits retrograde urine flow, predisposing patients to recurrent UTIs, renal scarring, and in some cases, long-term renal dysfunction (1).

The primary goal of VUR management is to prevent recurrent infections and progressive renal injury. Current treatment options include observation, continuous antibiotic prophylaxis (CAP), endoscopic injection therapy (STING), and open surgical correction (ureteroneocystostomy) (2). According to recent European Association of Urology (EAU, 2023) and American Urological Association (AUA, 2020) guidelines, endoscopic treatment is typically recommended for low- to moderate-grade reflux (grades I–III), owing to its minimally invasive nature and low morbidity (3,4). However, its success rate decreases significantly in high-grade VUR. In such cases, open surgery remains the gold standard, particularly in the presence of renal scarring, anatomical anomalies, or failure of previous endoscopic interventions (4).

While STING is often favored for its simplicity and outpatient feasibility, proper patient selection is critical. Factors such as age, VUR grade, renal scarring, and anatomical variations should be considered when deciding between STING and open surgical approaches (5). This study aims to evaluate the outcomes of endoscopic and open surgical interventions in pediatric VUR over a 10-year period at a single center and to identify clinical factors associated with treatment success.

2. Materials ve Methods

We retrospectively reviewed children who underwent VUR surgery between January 2010 and December 2019. Data were collected from medical records, including demographics, clinical presentation, UTI history, and radiological findings. Patients with missing data, incomplete follow-up, neurogenic bladder, or previous bladder surgery were excluded. VUR was classified using the International Reflux Study system: Grades 1–3 (low/moderate) and Grades 4–5 (high) (6). Two surgical procedures were performed: STING (minimally invasive with Deflux) and UNC (open surgery for recurrent reflux). We assessed the relationship between gender, age, VUR side/grade, DMSA findings, UTI history, and surgical success.

In our study, treatment success for both STING and UNC was uniformly defined as the complete resolution of reflux on follow-up voiding cystourethrogram (VCUG), indicating radiological cure.

Although the methodology is clearly described, it should be noted that neither urodynamic studies nor uroflowmetry analyses were performed. The absence of these assessments represents a limitation of the study and should be acknowledged accordingly.

Statistical Analysis

Statistical analyses were performed using SPSS 22.0. Continuous variables were expressed as mean ± SD, and categorical variables as frequency and percentage. The Kolmogorov-Smirnov and Shapiro-Wilk tests assessed variable distribution. The Mann-Whitney U and Chi-Square tests were used for inter-group comparisons, with $p < 0.05$ considered significant.

Ethics Approval

The study protocol was approved by the Local Ethics Committee (Protocol Number: 2012-KAEK-15/2158) and was conducted in accordance with the Declaration of Helsinki.

3. Results

The study included 157 patients (113 females, 44 males) with a mean age of 69.4 ± 44.6 months. There was no significant age difference between boys and girls ($p > 0.05$). The mean follow-up duration was 30.9 ± 21.7 months, with no gender-based difference ($p > 0.05$). Patients were stratified into three age groups: 0–6 years (57.3%), 6–12 years (37%), and 12–18 years (5.7%).

Voiding cystourethrography (VCUG) revealed unilateral reflux in 58.5% and bilateral in 41.4% of patients. Among unilateral cases, reflux was more frequently left-sided (69.5%). Reflux severity was classified as low (0.7%), moderate (64.3%), and high (35%). Renal scarring on DMSA was observed in 47.7% of patients. Female patients had a significantly higher rate of preoperative UTIs ($p = 0.006$) and low-grade reflux ($p = 0.023$). No significant gender differences were found in reflux

laterality or DMSA findings. Relevant demographic and radiological data are presented in Tables 1–3.

Laterality of vesicoureteral reflux (VUR) did not significantly differ across age groups, UTI history, VUR severity, or DMSA findings. Bilateral reflux was most common overall, particularly in children aged 6–12 years and those with a history of UTI or high-grade VUR. Left-sided reflux predominated in older children and those without renal scarring, whereas right-sided reflux was least frequent in all subgroups. None of the observed differences reached statistical significance.

Among 153 patients undergoing STING as the initial procedure, the overall success rate after the first injection was 38.6%, increasing to 59.5% after multiple applications. STING success did not significantly differ by gender, reflux side, DMSA findings, or grade ($p > 0.05$). However, success rates were significantly higher in older children ($p = 0.032$) and in those with low/moderate-grade reflux ($p = 0.015$). Four patients underwent primary open ureteroneocystostomy (UNC) with no recurrence. In total, 35 patients received UNC, with an overall success rate of 85.7%. No significant differences in UNC outcomes were found based on gender, age, reflux grade or laterality, or renal scarring ($p > 0.05$). Summary of STING and UNC outcomes are provided in Tables 4–6.

Postoperative urinary tract infections (UTIs) occurred in 38.1% of patients overall. The incidence was significantly higher in females (48.8%) compared to males (9.4%) ($p=0.0001$). No significant associations were found between postoperative UTI and age group, VUR laterality, or reflux grade. Although UTI rates varied slightly across subgroups—ranging from 29.2% in bilateral VUR to 46.8% in left-sided VUR, and from 34.3% in high-grade to 39.8% in low-to-moderate VUR—these differences were not statistically significant.

Table 1. Demographic data and radiologic findings of patients

		n(%)
Gender	**Male**	44 (%28,1)
	Female	113 (%71,9)
Age Range	**0-6 years**	90(%57,3)
	6-12 years	58(%37)
	12-18 years	9(%5,7)
Reflux Side	**Right**	28(%17,8)
	Left	64(%40,8)
	Bilateral	65(%41,4)
Reflux Grade	**Low**	1(%0,7)
	Moderate	101(%64,3)
	High	55(%35)
Scintigraphy Findings	**Scar Present**	75(%47,7)
	No Scar	82(%52,3)
Total		157 (%100)

Table 2. Preoperative Findings of Boys and Girls

		Gender						
		Male		**Female**		**Total**		
		N	**%**	**n**	**%**	**n**	**%**	***P***
Age Range	**0-6 years**	27	61,4	63	55,8	90	57,3	0,693
	6-12 years	14	31,8	44	38,9	58	36,9	
	12-18 years	3	6,8	6	5,3	9	5,7	
UTI History	**Present**	36	81,8	109	96,5	145	92,4	**0,006**

	Absent	8	18,2	4	3,5	12	7,6	
VUR Side	**Right**	7	15,9	21	18,6	28	17,8	0,604
	Left	16	36,4	48	42,5	64	40,8	
	Bilateral	21	47,7	44	38,9	65	41,4	
VUR Grade	**Low+Moderate**	22	50,0	80	70,8	102	65,0	**0,023**
	High	22	50,0	33	29,2	55	35,0	
DMSA Findings	**Scar Present**	21	47,7	54	47,8	75	47,8	1
	No Scar	23	52,3	59	52,2	82	52,2	

Table 3. Preoperative Findings of Patients According to Renal Scintigraphy Results

		Renal Scintigraphy Findings						
		Scar Present		**No Scar**		**Total**		
		N	**%**	**n**	**%**	**n**	**%**	***P***
Age Range	**0-6 years**	41	45,6	49	54,4	90	100,0	0,775
	6-12 years	29	50,0	29	50,0	58	100,0	
	12-18 years	5	55,6	4	44,4	9	100,0	
UTI History	**Present**	69	47,6	76	52,4	145	100,0	1
	Absent	6	50,0	6	50,0	12	100,0	
VUR Grade	**Low+Moderate**	48	47,1	54	52,9	102	100,0	0,808
	High	27	49,1	28	50,9	55	100,0	

Table 4. Association Between Preoperative Findings and the Success of the First STING Intervention

		Results of First STING Application						
		No Success		**Success**		**Total**		
		n	**%**	**n**	**%**	**N**	**%**	***p***
Gender	**Male**	27	62,8	16	37,2	43	100,0	0,976
	Female	67	60,9	43	39,1	110	100,0	
Age Range	**0-6 years**	60	68,2	28	31,8	88	100,0	**0,032**
	6-12 years	32	56,1	25	43,9	57	100,0	
	12-18 years	2	25,0	6	75,0	8	100,0	
VUR Grade	**Low+Moderate**	54	54,0	46	46,0	100	100,0	**0,015**

	High	40	75,5	13	24,5	53	100,0	
VUR Side	**Right**	16	57,1	12	42,9	28	100,0	0,169
	Left	35	54,7	29	45,3	64	100,0	
DMSA Findings	**Scar Present**	49	69,0	22	31,0	71	100,0	0,073
	No Scar	45	54,9	37	45,1	82	100,0	

Table 5. Effect of Preoperative Findings on the Overall Success of Single and Multiple STING Applications

		Results of Multiple STING Application						
		Present		**Absent**		**Total**		
		N	**%**	**N**	**%**	**n**	**%**	***P***
Gender	**Male**	26	60,5	17	39,5	43	100,0	1
	Female	65	59,1	45	40,9	110	100,0	
Age Range	**0-6 years**	48	54,5	40	45,5	88	100,0	0,333
	6-12 years	37	64,9	20	35,1	57	100,0	
	12-18 years	6	75,0	2	25,0	8	100,0	
DMSA Findings	**Scar Present**	39	54,9	32	45,1	71	100,0	0,286
	No Scar	52	63,4	30	36,6	82	100,0	
Reflux Side	**Right**	16	57,1	12	42,9	28	100,0	0,614
	Left	41	64,1	23	35,9	64	100,0	
	Bilateral	34	55,7	27	44,3	61	100,0	
Reflux Grade	**Low+Moderate**	65	65,0	35	35,0	100	100,0	0,082
	High	26	49,1	27	50,9	53	100,0	

Table 6. Results of Ureteroneocystostomy Based on Preoperative Findings of the Patients

		Ureteroneocystostomy Success						
		Present		**Absent**		**Total**		
		n	**%**	**N**	**%**	**N**	**%**	***P***
Gender	Male	6	75,0	2	25,0	8	100,0	0,568
	Female	24	88,9	3	11,1	27	100,0	
Age Range	0-6 years	21	87,5	3	12,5	24	100,0	0,673
	6-12 years	8	80,0	2	20,0	10	100,0	
	12-18 years	1	100,0	0	0,0	1	100,0	
VUR Grade	Low+Moderate	20	90,9	2	9,1	22	100,0	0,337
	High	10	76,9	3	23,1	13	100,0	

VUR Side	Right	8	100,0	0	0,0	8	100,0	0,558
	Left	8	80,0	2	20,0	10	100,0	
	Bilateral	14	82,4	3	17,6	17	100,0	
DMSA Findings	Scar Present	17	81,0	4	19,0	21	100,0	0,627
	No Scar	13	92,9	1	7,1	14	100,0	

4. Discussion

Over the past three decades, minimally invasive techniques such as subureteric injection (STING) have become an established approach for managing vesicoureteral reflux (VUR), offering effective outcomes with minimal morbidity and avoiding hospitalization (7). In this study, we evaluated treatment outcomes and predictors of success in children undergoing STING or ureteroneocystostomy (UNC).

VUR is more commonly observed in males, who often present earlier and with higher-grade reflux, whereas females are typically diagnosed later with lower-grade disease and have reduced likelihood of spontaneous resolution (8,9). In our cohort, which included 113 females and 44 males, no significant differences were found in age or follow-up duration. VUR prevalence declined with age, and 47.7% of patients demonstrated renal scarring, although no significant associations were observed between scarring and gender, reflux grade, or age.

Consistent with prior studies, boys exhibited a higher frequency of high-grade reflux, while girls had more frequent urinary tract infection (UTI)-related admissions (10). The initial success rate of STING in our cohort was 38.6%, which is lower than reported rates in similar pediatric populations, where success typically ranges from 50% to 80%, depending on reflux severity and injection technique (11,12). This discrepancy may be due to the lack of preoperative assessment of voiding patterns and the absence of urodynamic testing in our protocol, which may have contributed to suboptimal patient selection. Comparable studies using preoperative functional evaluations have reported higher STING success, supporting the need for such assessments in routine practice.

Although statistical significance was not reached, a higher rate of repeat STING was observed among older children and those with low to moderate-grade reflux, possibly reflecting a more conservative approach in these subgroups or a preference to avoid open surgery. In contrast, patients with high-grade reflux were more likely to undergo early UNC, consistent with known limitations of endoscopic treatment in severe cases.

Repeat STING increased the cumulative success rate to 59.5%. Better outcomes were seen in younger patients and in low-grade reflux, while success remained lowest in high-grade reflux (49.1%). This supports a selective use of STING in appropriately stratified patients.

UNC provided superior outcomes, with an overall success rate of 85.7%, including 100% in right-sided, 80% in left-sided, and 82.4% in bilateral reflux. In low to moderate reflux, success was 90.9%, and in high-grade reflux, 76.9%. These outcomes are modest compared to the 95–99% success rates reported in the literature for UNC (13,14), possibly due to surgical complexity, patient-specific factors, or institutional variations. Further investigation is warranted to determine the reasons for this relative discrepancy.

Postoperative UTIs occurred in 38.1% of patients, with significantly higher rates in females (48.8% vs. 9.4% in males), consistent with previous findings (10,15). This gender disparity should be interpreted in the context of voiding dysfunction and genital hygiene practices, which were not systematically evaluated in our study. These unmeasured variables may have contributed to UTI persistence and underscore the importance of incorporating behavioral and functional assessments into post-treatment follow-up.

This study has several limitations. First, the retrospective design introduces inherent bias and limits causal inference. More importantly, the absence of urodynamic and uroflowmetry evaluations restricted our ability to assess lower urinary tract function, a known contributor to treatment failure. In addition, variation in surgical technique and institutional protocols over the study period may have influenced outcomes. Future prospective studies should incorporate functional assessments and standardized surgical criteria to better define optimal management pathways.

In conclusion, our findings highlight the importance of individualized treatment in pediatric VUR. STING may be suitable for select patients with low-grade reflux, while UNC remains the preferred option for those with high-grade disease, renal scarring, or impaired renal function. The persistence of UTIs, especially among females, emphasizes the need for a comprehensive approach that includes behavioral counseling, hygiene education, and voiding assessment**.** A multidisciplinary and patient-centered strategy is essential to optimize renal outcomes and quality of life in children with VUR.

Disclosure

Conflict of interest: No conflict declared, Informed Consent: N/ARegistry and the Registration No: N/AAnimal Studies N/A

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