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Distribution of Meatal Stenosis According to Age Following the Dorsal Slit Technique and Its Effects on the Urinary System: Cross-Sectional Observational Study

Dorsal Slit Tekniği Sonrası Meatal Stenozun Yaşlara Göre Dağılımı ve Üriner Sistemdeki Etkileri: Kesitsel Gözlemsel Çalışma

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ABSTRACT Objective: Meatal stenosis after circumcision is a concerning complication that may require various interventions. Its age-related distribution remains unclear, and its effects on the urinary system are not fully understood. We aimed to evaluate the age-related distribution and urinary system effects of meatal stenosis following the dorsal slit technique. **Material and Methods:** A total of 5,422 cases who underwent circumcision using the dorsal slit technique were evaluated for meatal stenosis. Cases diagnosed with meatal stenosis were divided into 3 groups based on the age range. Surgical or non-surgical interventions were performed on the cases. Cases with anomalies in the urogenital system were excluded from the study. The age-related distribution and urinary system effects of these cases were evaluated. **Results:** Meatal stenosis was detected in 377 (6.95%) of the 5,422 circumcised cases. The age-related distribution of meatal stenosis and the frequency of undergoing meatoplasty were statistically significant between patients who underwent meatoplasty and those who did not ($p<0.05$). However, the comparison of urinary system effects by age group between these 2 groups was not found to be statistically significant ($p>0.05$). **Conclusion:** This study demonstrated that meatal stenosis is a common complication following the dorsal slit technique, that younger age at circumcision is associated with a higher incidence of meatal stenosis, and that meatoplasty procedures are more frequently required in such cases. Furthermore, the potential effects of meatal stenosis on the urinary system should be carefully considered in affected patients.

Keywords: Circumcision; complication; meatal stenosis; urinary system; dorsal slit

ÖZET Amaç: Sünnet sonrası meatal stenoz, çeşitli müdahaleler gerektirebilecek endişe verici bir komplikasyondur. Yaşlara göre dağılımı belirsizliğini korumakta ve üriner sistemdeki etkileri tam olarak bilinmemektedir. Çalışmamızda, dorsal slit tekniği sonrası meatal stenozun yaşlara göre dağılımı ve üriner sistemdeki etkilerini değerlendirmeyi amaçladık. **Gereç ve Yöntemler:** Dorsal slit tekniği ile sünnet yapılan 5.422 olgu meatal stenoz açısından değerlendirildi. Meatal stenoz tespit edilen olgular yaş aralığına göre 3 gruba ayrıldı. Olgulara cerrahi veya cerrahi dışı işlem uygulandı. Ürogenital sistemde anomalisi bulunan olgular çalışma dışı bırakıldı. Bu olguların, yaşlara göre dağılımı ve üriner sistemdeki etkileri değerlendirildi. **Bulgular:** Sünnet yapılan 5.422 olgunun 377'sinde (%6,95) meatal stenoz tespit edildi. Meatoplasti yapılan ve meatoplasti yapılmayan olguların meatal stenoz açısından yaşlara göre dağılımı ve yaş gruplarına göre meatoplasti operasyonu geçirmesi istatistiksel olarak anlamlıydı ($p<0,05$). Meatoplasti yapılan ve meatoplasti yapılmayan olguların üriner sistemdeki etkilerinin yaş gruplarına göre karşılaştırılması ise istatistiksel olarak anlamlı bulunmadı ($p>0,05$). **Sonuç:** Dorsal slit tekniği sonrası meatal stenozun sık görüldüğü, sünnet yaşı ne kadar erken ise meatal stenozun daha sık görüldüğü ve meatoplasti operasyonunun da daha sık yapıldığı bu çalışmada gösterilmiştir. Ayrıca meatal stenoz tespit edilen olguların üriner sistemdeki etkilerini akılda tutmak gerekmektedir.

Anahtar Kelimeler: Sünnet; komplikasyon; meatal stenoz; üriner sistem; dorsal slit

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Circumcision in males ranks among the most commonly conducted surgical interventions and involves the excision of the preputial skin.[1] This procedure is typically undertaken for a variety of motivations, including religious, cultural, traditional, ritualistic, or clinical indications.[2] Globally, the prevalence of male circumcision is reported to be approximately 40%.[3] Medical literature indicates that circumcision contributes to lowering the incidence of urinary tract infections and pyelonephritis, in addition to reducing the risk of penile cancer and transmission of sexually transmitted infections.[4]

Circumcision is associated with several potential complications, among which meatal stenosis (MS) is recognized as a notable late-onset outcome.[5,6] One proposed mechanism suggests that injury to or ligation of the frenular artery may reduce blood flow to the distal meatus, resulting in mucosal ischemia and subsequent narrowing of the meatus.[7-10] This risk is particularly emphasized when circumcision is carried out during the neonatal period.[11] The surgical excision of the foreskin can provoke inflammation and scarring in the meatal region. Moreover, loss of frenular vascular support, persistent inflammation (chronic meatitis), and irritation from exposure of the meatus may all contribute to the development of MS, especially when exacerbated by chemical dermatitis from urine.[12] Although infrequent, MS can lead to a range of urinary tract issues, such as voiding difficulties, retention of urine, recurrent infections, bladder dysfunction, vesicoureteral reflux, hydronephrosis, and, in severe cases, renal insufficiency.[13,14] Obstructive uropathy has also been identified, albeit rarely, as a downstream complication of MS after circumcision.[12]

Symptoms are often masked in infants and young children who wear diapers, so diagnosis is typically delayed until the toilet training phase. MS may remain asymptomatic until urinary control is achieved.[12] The most commonly reported symptoms include deviations in urinary flow, burning during urination, bleeding, urinary frequency, and incontinence.[7,15] Although the diagnosis of MS remains controversial, certain criteria are generally accepted, including a urethral meatus diameter of less than 5F, failure to pass a 6F catheter through the urethral meatus, the presence of a visibly narrowed urethral meatus, and signs of obstruction on uroflowmetry.[11,12,16]

MS is typically categorized into 3 levels of severity: mild, moderate, and severe. While mild presentations often do not necessitate any medical intervention, cases of greater severity may require therapeutic measures such as the application of topical agents, urethral dilatation, or manual techniques to relieve the narrowing.[11,17] In instances where the stenosis is particularly advanced, surgical intervention-most commonly meatoplasty-is generally indicated. For diagnostic evaluation, imaging of the urinary tract, including both upper and lower tract ultrasonography, may not be universally essential. However, such assessments can be valuable in individuals presenting with recurrent urinary tract infections, difficulties in voiding, urinary retention, or ongoing symptoms.[12,18]

In this study, the retrospective, single-center results of cases who underwent circumcision using the dorsal slit technique (DST) were presented to determine the distribution of MS by age and its effects on the urinary system.

MATERIAL AND METHODS

This retrospective study was conducted between 2011-2022. A total of 5,422 children underwent circumcision using the DST method, and MS was identified in 377 cases. This was a single-center, retrospective, cross-sectional observational study. Clinical records of individuals who had received either surgical or non-surgical treatment were evaluated in this study. Informed consent was obtained from all participants prior to data collection. The research was conducted in compliance with the ethical principles outlined in the Declaration of Helsinki. Retrospective data analysis was carried out using the hospital's electronic medical records system. Patients who met the exclusion criteria were omitted, and statistical analyses were performed on the remaining study population.

ETHICS APPROVAL

The study was approved by Tokat Gaziosmanpaşa University Faculty of Medicine Non-Interventional Scientific Research Ethics Committee (date: December 13, 2024; no: E-15235480-050.04-509242).

Cases who underwent or did not undergo meatoplasty were divided into 3 groups: Group 1 (ages 0-4), Group 2 (ages 5-8), and Group 3 (ages 9-12). No prior study was referenced in determining the age ranges; the groups were defined in this manner to ensure clarity of the study. A total of 377 primary patients who underwent circumcision using the DST method and were later diagnosed with MS during follow-up were included in the study. Cases under follow-up for vesicoureteral reflux, neurogenic bladder, or hydroureteronephrosis, and those with hypospadias, buried penis, balanitis xerotica obliterans, trauma, or MS resulting from other circumcision techniques were excluded from the study. The age distribution of the patients, the severity of the stenosis, the surgical method applied, the effects on the urinary system, and recurrence status were recorded.

Preoperative physical examination, urinary system ultrasonography, post-void residual urine measurement, and urine and renal function tests were performed in cases who underwent or did not undergo meatoplasty. Uroflowmetry could not be performed due to technical reasons. Since average bladder wall thickness in children ranges between 1.5-3 mm, a thickness above 3 mm was accepted as abnormal. Bladder wall thickness, bilateral hydroureteronephrosis, and renal parenchymal thickness were evaluated via ultrasonography. Postoperatively, physical examinations and the same tests were performed at regular intervals. MS and its effects on the urinary system were followed up for a minimum of 2 years. All circumcision and MS-related surgical procedures were performed by the same physician. Permission was obtained from the patients' families for the photographs taken during the meatoplasty procedures. Images were used in the study with signed permission from the patient's family.

SURGICAL TECHNIQUES

Physical examination, urinary system ultrasonography, urinalysis, and kidney function tests were performed for MS cases. A visibly narrowed urethral meatus and a meatal diameter of less than 5F were accepted as criteria for meatoplasty (Figure 1, Figure 2a). Before the meatoplasty procedure, the meatal

FIGURE 1: The appearance of meatal stenosis a narrow point on physical examination

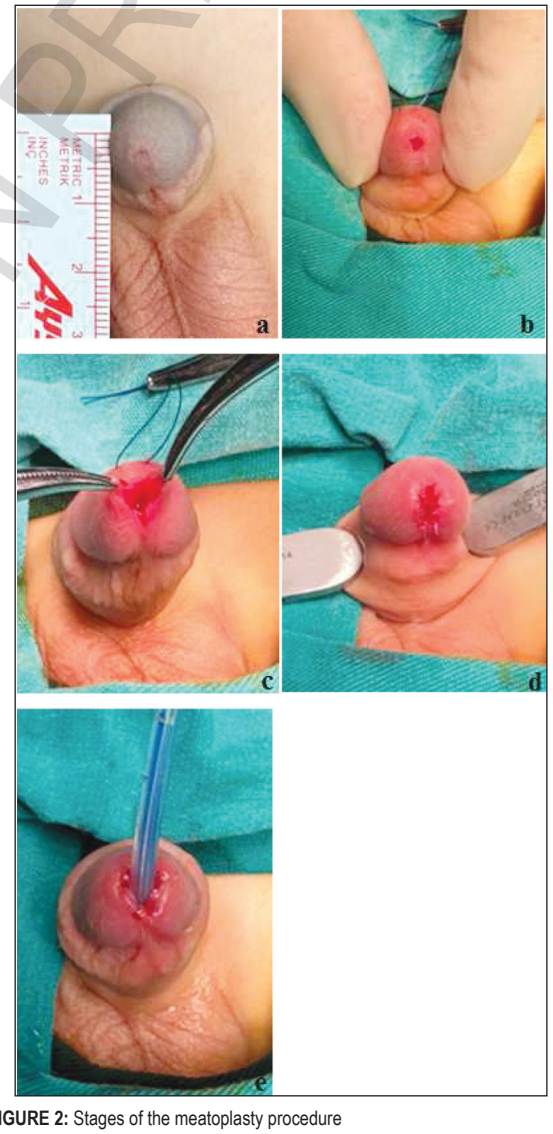

FIGURE 2: Stages of the meatoplasty procedure

opening was remeasured under anesthesia (Figure 2a). The meatus was gently dilated using a soft tube or pediatric clamp (Figure 2b). To widen the opening, a V-shaped incision was made beneath the meatus, at the lower part of the penis (Figure 2c). To reapproximate the tissue and support healing, suturing was performed with 5/0 Vicryl at 3-4 points (Figure 2d). To prevent re-narrowing of the meatus, a silicone catheter was placed, and the procedure was completed (Figure 2e). Meatoplasty was performed in a total of 305 cases, and the average duration of the procedure was 20-30 minutes. The catheters were removed on the 3rd postoperative day.

Urethral dilatation was performed under local anesthesia using pediatric soft bougies, once daily during the first month, once weekly for the following 3 months, and then once monthly, until the stricture resolved, provided that appropriate conditions were met. Manual opening of the stricture was also performed once monthly using an antibiotic ointment and thumbs to separate the membranous stenosis.

STATISTICAL ANALYSIS

All statistical analyses were carried out using MedCalc software (version 20.009; Ostend, Belgium). Descriptive statistics included number, mean, standard deviation, frequency, percentage, median, and interquartile range (25th-75th percentiles). To assess the distribution of numerical variables, the Kolmogorov-Smirnov test was applied. Since the data did not exhibit a normal distribution pattern, comparisons between groups were made using the Mann-Whitney U test. Categorical variables were analyzed via the chi-square test. Numerical outcomes were visualized using box-and-whisker plots, while categorical results were presented in the form of stacked bar charts. A p value below 0.05 was considered statistically significant in all analyses.

RESULTS

MS was detected in 377 (6.95%) of the circumcised children. Group 1 comprised 262 (69.5%) cases, Group 2 included 77 (20.4%) cases, and Group 3 consisted of 38 (10.1%) cases (Table 1). Meatoplasty was performed in 305 (80.9%) cases, while 72 (19.1%) cases did not undergo meatoplasty. The mean age of patients who underwent meatoplasty was 35.50 months, compared to 60.22 months in those who did not. The age-related distribution of MS between patients who underwent and did not undergo meatoplasty was statistically significant ($p<0.0001$) (Table 2, Figure 3). When comparing the rates of undergoing meatoplasty among different age groups, 226 (86.3%) cases in Group 1, 59 (76.6%) cases in Group 2, and 20 (52.6%) cases in Group 3 underwent the procedure. The difference in meatoplasty rates among age groups was statistically significant ($p<0.0001$) (Table 3, Figure 4). In the comparison of urinary system effects in patients who underwent meatoplasty by age group, no statistically significant differences were found for bladder wall thickening ≥3 mm, bilateral hydroureteronephrosis, kidney function test abnormalities, or urinary infection ($p>0.05$) (Table 4). In the comparison of urinary system effects in patients who did not undergo meatoplasty by age group, no statistically significant differences were found for bladder wall thickening ≥3 mm, bilateral hydroureteronephrosis, kidney function test abnormalities, or urinary infections ($p>0.05$) (Table 5).

TABLE 1: Frequency and percentage distribution of age groups

	n	%
Group 1 (0-4 age)	262	69.5
Group 2 (5-8 age)	77	20.4
Group 3 (9-12 age)	38	10.1
Total	377	100.0

TABLE2: Data on the ages of meatal stenosis patients

	Meatoplasty (-)						Meatoplasty (+)						
	n	Mean	SD	Median	25P	75P	n	Mean	SD	Median	25P	75P	p value
Age (month)	72	60.22	41.64	54.0	24.0	90.0	305	35.50	31.76	24.0	10.0	49.0	<0.0001*

*Mann-Whitney U test results indicate a significant difference at the <0.05 level; SD: Standard deviation

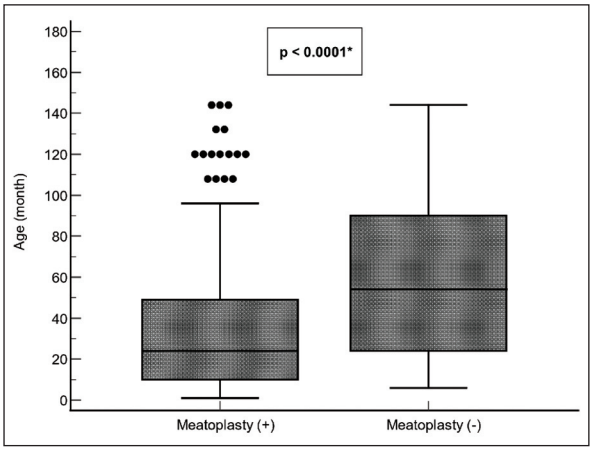

FIGURE 3: Graphical data on the ages of meatal stenosis patients

TABLE 3: Comparison of the occurrence of meatoplasty according to age groups

	Group 1 (0-4 age)		Group 2 (5-8 age)		Group 3 (9-12 age)		
	n	%	n	%	n	%	p value
Meatoplasty (-)	36	13.7	18	23.4	18	47.4	<0.0001*
Meatoplasty (+)	226	86.3	59	76.6	20	52.6	

*Chi-square test results indicate a significant difference at the <0.05 level

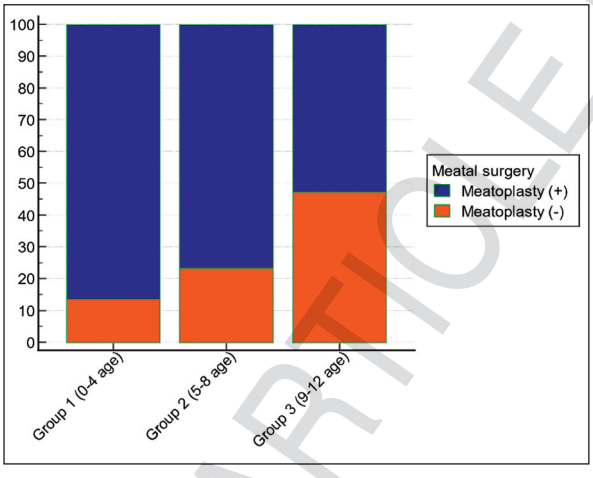

FIGURE 4: Graphical data on the occurrence of meatoplasty according to age groups

Recurrence of MS was observed in 16 of the 305 patients who underwent meatoplasty. As the recurrences were of moderate severity, intermittent urethral dilation was performed, resulting in complete resolution within 1-2 years. Bladder wall thickening did not regress in 6 patients. In 4 patients, although hydroureteronephrosis improved, it did not resolve completely. However, no cases of kidney failure were observed in any of the patients. The patients are still undergoing periodic follow-up. No recurrences were observed in any of the 72 patients who did not undergo meatoplasty, and the effects on the urinary system were completely resolved.

DISCUSSION

MS is an abnormal narrowing of the glandular opening in males.[19] It is a late complication that can occur after circumcision.[20,21] Although the primary etiology of MS remains unclear, several theories have been proposed. Various hypotheses have been suggested to explain the development of MS, with one widely accepted explanation being prolonged contact of the meatus with urine containing high levels of ammonia.[7] Additional irritants, such as moisture from soiled diapers (including underwear, fecal matter, and urine), may also contribute to persistent local irritation when the protective foreskin is absent, potentially resulting in chronic inflammation and meatitis. Disruption or ligation of the frenular artery may compromise blood supply to the distal meatus, thereby inducing ischemia of the surrounding mucosa. Less commonly, MS may also be associated with conditions such as balanitis xerotica obliterans, trauma, or surgical repair of hypospadias.[7-10] In the present study, 262 (69.5%) patients with MS were categorized as Group 1, with findings suggesting that chemical irritation from urinary ammonia was the predominant contributing factor. In Groups 2 and 3, which included 77 (20.4%) and 38 (10.1%) cases respectively, MS was most plausibly linked to vascular compromise caused by frenular artery damage or ligation.

MS frequently remains clinically silent, with symptoms often becoming evident only after the onset of toilet training.[7,8] As MS is typically a delayed complication, its true incidence remains difficult to determine.[8] Reported rates of MS following neonatal circumcision vary considerably, ranging from 0.2% to 20.4%.[5,8,11,22,23] Morris and Krieger estimated the incidence at approximately 0.7% in circumcised males.[8] In a longitudinal study involving 206 circumcised boys, 13 (6.3%) cases were diagnosed with MS. Additionally, Yegane et al. conducted a cross-sectional analysis in 2006, identifying late-onset com-

TABLE 4: Comparison of the effects on the urinary system in meatoplasty patients according to age groups

		Meatoplasty (+)						
		Group 1 (0-4 age)		Group 2 (5-8 age)		Group 3 (9-12 age)		
		n	%	n	%	n	%	p value
Bladder wall thickening ≥3 mm	Not present	212	93.8	55	93.2	17	85.0	0.329
	Present	14	6.2	4	6.8	3	15.0	
Bilateral hydroureteronephrosis	Not present	216	95.6	56	94.9	18	90.0	0.542
	Present	10	4.4	3	5.1	2	10.0	
Kidney dysfunction	Not present	219	96.9	57	96.6	19	95.0	0.899
	Present	7	3.1	2	3.4	1	5.0	
Urinary tract infection	Not present	214	94.7	54	91.5	18	90.0	0.516
	Present	12	5.3	5	8.5	2	10.0	

*Chi-square test results indicate a significant difference at the <0.05 level

TABLE 5: Comparison of the effects on the urinary system in non-meatoplasty patients according to age groups

		Meatoplasty (-)						
		Group 1 (0-4 age)		Group 2 (5-8 age)		Group 3 (9-12 age)		
		n	%	n	%	n	%	p value
Bladder wall thickening ≥3 mm	Not present	32	88.9	16	88.9	17	94.4	0.789
	Present	4	11.1	2	11.1	1	5.6	
Bilateral hydroureteronephrosis	Not present	34	94.4	17	94.4	18	100.0	0.594
	Present	2	5.6	1	5.6	0	0.0	
Kidney dysfunction	Not present	34	94.4	17	94.4	18	100.0	0.594
	Present	2	5.6	1	5.6	0	0.0	
Urinary tract infection	Not present	32	88.9	16	88.9	18	100.0	0.336
	Present	4	11.1	2	11.1	0	0.0	

*Chi-square test results indicate a significant difference at the <0.05 level

plications of circumcision in 7.39% of patients, with MS specifically observed in 0.9% of cases.[13] Another investigation by Weiss et al. which assessed 141 circumcised children in Nigeria, reported MS in 3.5% of cases during a 6-week postoperative period.[24] The broad variation in MS prevalence across studies may be attributed to multiple factors, including patient age, surgeon experience, surgical method, inconsistencies in diagnostic criteria, and variations in the adequacy of postoperative follow-up.[11,13] In our study, 377 (6.95%) cases of MS were detected. The higher rate of MS compared to other studies may be due to the wide age range included in the study, the large sample size, and the unnecessary use of bipolar cautery for bleeding in the frenular artery region during the surgical procedure. MS was detected between 1 and 3 months post-circumcision in our study, which is consistent with the literature.

MS is most commonly observed following neonatal circumcision and is seldom seen in uncircumcised male children.[6,12,25] Reported post-circumcision MS incidence rates among neonates vary widely, ranging from 0.2% to 20.4%.[11,25,26] For instance, Van Howe's research indicated that while none of the uncircumcised male children developed MS, the condition was present in 7.29% of those who had undergone circumcision shortly after birth. Based on his findings, MS was identified as a potentially leading complication associated with neonatal circumcision.[22] Another investigation documented an MS incidence of 20.4% among neonatally circumcised males.[11] By contrast, in a larger cohort, Eroğlu et al. reported a substantially lower incidence of 0.31%, noting just 3 cases of MS among 1,050 neonatally circumcised infants.[27] In our study, a significant difference in MS was observed in Group 1, which in-

cluded 262 (69.5%) cases of neonates, compared to the other groups, and it was determined that the earlier the age at circumcision, the higher the risk and severity of MS.

There are many studies showing the relationship between circumcision techniques and MS. Despite the clinical relevance of MS, the literature contains limited evidence regarding its association with the DST. In a comparative study involving 60 pediatric patients, Karakoyunlu et al. evaluated outcomes between the dorsal slit and sleeve circumcision methods. Their findings indicated that the sleeve technique, which maintains the integrity of the frenular artery, offers better hemostasis, lowers the risk of localized ischemia, and may reduce both postoperative discomfort and complication rates.[28] Azizoglu et al. observed MS in one patient circumcised using the DST among 166 patients in whom alisklamp and dorsal slit circumcision techniques were compared.[29] In our study, it was shown that the earlier the circumcision age using DST, the more frequently MS was observed, and the more often meatoplasty was performed. The difficulty in preserving the frenular artery in this technique may be an important reason for the higher risk of MS.

Recurrent episodes of pyelonephritis and obstructive uropathy are frequently overlooked consequences of MS following circumcision.[12,13] These complications have the potential to significantly increase the risk of renal injury and eventual kidney failure.[12] Although imaging techniques such as ultrasonography are not routinely indicated for every patient, they are advisable in individuals presenting with urinary tract infections, voiding abnormalities, urinary retention, or persistent symptoms.[30] In a study published by Joudi et al. in 2010, thorough clinical examinations and diagnostic testing were utilized to assess MS incidence within 1 year after neonatal circumcision. The study reported that 20.4% of the patients exhibited severe MS, while 11.1% showed bladder wall thickening and bilateral hydronephrosis; renal scarring was detected in 0.75% of the cases.[11] Additionally, a report from the University of Kansas Medical Center by Linshaw described 2 infants with MS-related obstructive kidney disease. One infant had pronounced dysuria, intermittent urine flow, and a palpable enlargement of the left kidney, whereas the second exhibited hematuria. Ultrasonography in both cases revealed bilateral hydronephrosis and hydroureter.[18] Obstructive uropathy is one of the few renal diseases that are initially treatable and reversible. Since MS can cause obstruction in the urinary tract, it is recommended to screen patients for obstructive uropathy in cases of proven MS, treat them before permanent kidney damage occurs, and conduct postoperative follow-up. In our study, although the differences were not statistically significant between the groups, urinary system involvement was higher in severe MS cases that underwent meatoplasty, and damage persisted in follow-up examinations. For this reason, some patients are still being monitored with ultrasonography and other tests to prevent permanent kidney damage.

LIMITATIONS

Although the single-center and retrospective nature of the study, the lack of clear diagnostic criteria for the disease, delays in diagnosis, and relatively short follow-up periods are considered limiting factors, the most significant limitation is the absence of uroflowmetry, which plays a crucial role in the diagnosis of the disease.

CONCLUSION

We would like to emphasize that when performing circumcision with the DST, especially in neonates and at an early age, care should be taken to preserve the frenular artery, unnecessary use of bipolar cautery for bleeding should be avoided, and the procedure should be performed by experienced hands. We emphasize the importance of preserving the frenular artery during circumcision with DST and recommend that this technique be performed by skilled hands. To assess the effects of MS on the urinary system, we recommend using ultrasonography, a useful method, both before and after treatment. Additionally, we consider this study to be the largest series to show the relationship between DST and MS, and we believe that these results are significant for guiding future studies in this field.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Kenan Yalçın, Engin Kölükçü, Ahmet Burak Gürpınar, Yunus Emre Kuyucu;* ***Design:*** *Kenan Yalçın, Engin Kölükçü;* ***Control/Supervision:*** *Kenan Yalçın, Engin Kölükçü, Ahmet Burak Gürpınar, Yunus Emre Kuyucu;* ***Data Collection and/or Processing:*** *Kenan Yalçın, Engin Kölükçü, Ahmet Burak Gürpınar;* ***Analysis and/or Interpretation:*** *Kenan Yalçın, Engin Kölükçü;* ***Literature Review:*** *Kenan Yalçın, Engin Kölükçü;* ***Writing the Article:*** *Kenan Yalçın, Engin Kölükçü, Ahmet Burak Gürpınar, Yunus Emre Kuyucu;* ***Critical Review:*** *Kenan Yalçın, Engin Kölükçü, Ahmet Burak Gürpınar;* ***References and Fundings:*** *Kenan Yalçın, Engin Kölükçü, Ahmet Burak Gürpınar, Yunus Emre Kuyucu;* ***Materials:*** *Kenan Yalçın, Engin Kölükçü, Ahmet Burak Gürpınar, Yunus Emre Kuyucu.*

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