Uroflowmetry Before and After Meatotomy in Boys with Symptomatic Meatal Stenosis Following Neonatal Circumcision — A Long-term Prospective Study

Amos Neheman, Yishai H. Rappaport, Abd E. Darawsha, Ilan Leibovitch, and Itay A. Sternberg

OBJECTIVE   To assess uroflowmetry in the long-term follow-up of symptomatic meatal stenosis patients prior to and following meatotomy. Severity of symptoms and treatment success has been defined by patient history, physical examination, and witnessed voiding. Uroflowmetry might add objective parameters for the assessment, however long-term data are lacking.

METHODS   A prospective study following 25 symptomatic toilet-trained boys before and after meatotomy was performed with short and long-term follow-up after surgery. Patient history, physical examination, and uroflowmetry variables were recorded.

RESULTS   Fifteen patients were fully evaluable. Mean age at operation was 6.4 years (2.5-10.5) with an average follow-up of 43 months. All patients were symptomatic before surgery; complete symptomatic resolution was achieved in all patients at short-term follow-up, and in 12 at long-term follow-up. A stenotic meatus was seen in all patients before surgery, at long-term follow-up 12 of 15 (80%) had an open appearing meatus ($P = .0001$). Abnormal uroflowmetry pattern was present in 8 of 15 (53%) prior to surgery and 2 of 15 (13%) at long-term follow-up ($P = .02$). Normal maximal flow rate as defined by ICCS were seen in 5, 11, and 12 patients before, 1 month after and at long-term follow-up ($P = .06$ and 0.02, respectively). PVR improved significantly at long-term follow-up ($P = .0012$).

CONCLUSION   Symptom evaluation and physical examination should be the hallmark assessing children with meatal stenosis. Clinical assessment one month after surgery suffices and long-term follow-up is unnecessary. Uroflowmetry provides objective assessment as well as surgical success; however, it is unnecessary since it does not change the management.   UROLOGY 125: 191−195, 2019. © 2018 Elsevier Inc.

Primary urethral meatal stenosis is a common urologic problem occurring predominantly in circumcised boys. Reported incidences have varied, with as high as 20% in asymptomatic children with stenosis defined as meatal diameter <5 mm.[1] Stenosis alone does not warrant

intervention and is often asymptomatic; the estimated incidence of symptomatic meatal stenosis is 3%.[2] Symptoms are usually manifested after toilet training. The most common symptoms are deflected urinary stream, "thin and strong" stream and urinating to "long distance" but can also cause dysuria, urgency, straining, prolonged voiding time and rarely, hematuria, urinary tract infection and even urinary retention, and hydronephrosis.[1-3] Definitive treatments include surgical intervention and performing a ventral incision of the meatus — meatotomy, with low reported rates of restenosis and need for reoperation.[4,5] Successful surgery was traditionally defined as clinical improvement of subjective symptoms. A retrospective analysis of uroflowmetry before and after meatotoplasty has added an objective parameter for successful intervention.[6] Our objective was to assess long-term outcomes and uroflowmetry parameters after meatotomy in boys with symptomatic meatal stenosis following

neonatal circumcision. We hypothesize that uroflowmetry study would not change the management of meatal stenosis, currently assessed only by clinical evaluation.

MATERIALS AND METHODS

Study design: A prospective observational trial design was used. We assessed uroflowmetry parameters in a long-term follow-up after meatotomy for meatal stenosis in circumcised boys. The study protocol was approved by the medical center's ethical committee for experiments in humans. All patients' parents signed an informed consent form.

Study setting and population: Male children with clinically symptomatic meatal stenosis following neonatal circumcision referred to our clinic were eligible for recruitment. Inclusion criteria included previously toilet trained, ages 2-12 years who were able to urinate at request. Meatal stenosis was defined by physical examination as pinpoint, mild stenotic, or open.[7] Exclusion criteria included children that did not complete the study protocol, underlying neurologic abnormality, prior penile surgery, penile or meatal abnormality such as hypospadias or penile curvature, concurrent psychiatric medical treatment, active urinary tract infection and patients who were referred to our clinic with a primary diagnosis of meatal stenosis but after evaluation conditions other than meatal stenosis were proven to be the cause for urinary symptoms.

Study protocol: All patients were assessed by a symptom questionnaire, physical examination, and uroflowmetry:

1. Urinary symptoms were assessed by filling a "symptom questionnaire" by the parents and observation of urinary stream by the urologist either during the uroflowmetry or by matching a video recording provided by parents.
2. Meatal appearance was evaluated by a pediatric urologist for all eligible children, and was classified as: Normal (open), mildly stenotic (small) and stenotic (pin point).
3. Objective parameters were assessed by uroflowmetry and postvoid residual urine volume (PVR) using a portable bladder scan (Portscan+, Laborie Inc., Mississauga, ON, Canada) and were performed prior to surgical intervention. The trigger for initiating the uroflowmetry exam was the self-reported strong desire to void by the patient. Uroflowmetry parameters recorded included voided volume, maximal urine flow rate (Qmax), average flow rate (Qavg), and voiding time. Normal Qmax was defined according to the International Children Continence Society (ICCS): $Qmax^2$ > voided volume.[8] Flow Index (FI) using the formula by Franco et al. was assessed.[9] Flow pattern was determined by a pediatric urologist and assigned as either bell shaped (normal), flat, or staccato.

Surgery was performed under inhalatory mask using oxygen and nitrous oxide with sevoflurane to induce and maintain anesthesia. In all cases the crush meatotomy technique was performed. A straight clamp was used for crushing the tissue ventral to the meatus for 120 seconds, and division of the crushed tissue with straight scissors. Following surgery the parents were instructed to separate the cut edges of the meatus manually twice a day as well as to apply Dexpanthenol-Chlorhexidine cream for one week to prevent restenosis. Follow-up was scheduled at 1 month, and long term (>36 months) after surgery. At follow-up, children were evaluated for symptoms by filling a symptom questionnaire, meatal appearance was evaluated by physical examination and classified in the same manner as before surgery and uroflowmetry was performed .

Data analysis: Continuous variables were compared using the Wilcoxon (Mann-Whitney) test and dichotomous variables were compared using Fisher's exact test. Data were analyzed using SPSS software (statistical package for the social sciences, version 25, Chicago, IL). A P value of <.05 was considered significant.

RESULTS

The disposition of participants is presented in Figure 1. Long-term results were available for 15 patients, with median follow-up of 43 months. Clinical and uroflowmetric properties are presented in Tables 1 and 2, respectively. The mean age at surgery was 6.4 ± 2.9 years. All patients were symptomatic prior to surgery, mostly with multiple symptoms. Deflected and thin urinary stream were the most common complaints, in 13 and 9 patients, respectively. At 1 month after surgery all patients were symptom-free, and at long-term follow-up 12 remained without symptoms. Reported symptoms at long-term follow-up were deflected stream in 2 patients, and extended urinating time with long distance stream in 1 patient. Fourteen patients had pinpoint meatus at surgery and none at 1 month after surgery as well as at long-term follow-up (P = .0001). Three patients had a mild stenotic meatal appearance at long-term follow-up (Table 1).

Average maximal flow (Qmax) was 11.5 ± 6.0 mL/s (range 5.7-29.5), 15.3 ± 4.4 mL/s (9.6-27, P = .06) and 12.6 ± 4.0 mL/s (6-21.1, P = .56) before surgery, 1 month after surgery and at long-term follow-up, respectively. Abnormal Qmax ICCS was seen in 10, 4 (P = .06) and 3 (P = .02) patients before, 1 month after and at long-term follow-up, respectively. Qavg results were 7.8 ± 4.4 mL/s, 10 ± 2.6 mL/s (P = .10) and 7 ± 2.4 mL/s (P = .54) prior to surgery, 1 month after surgery and at long-term follow-up, respectively (Fig. 2).

FI score, first postulated by Franco et al,[9] was significant in postsurgical outcomes both for Qmax (P = .015) and Qavg (0.048) at short-term follow-up. FI was not significant at long-term follow-up, P = .934 for Qmax and P = .963 for Qavg.

Eight of fifteen (53%), 1 of 15 (6.7%) and 2 of 15 (13.3%) had flat uroflow curve before, 1 month after and at long-term follow-up after surgery (P = .0128 and P = .02, respectively). One patient had staccato-shaped
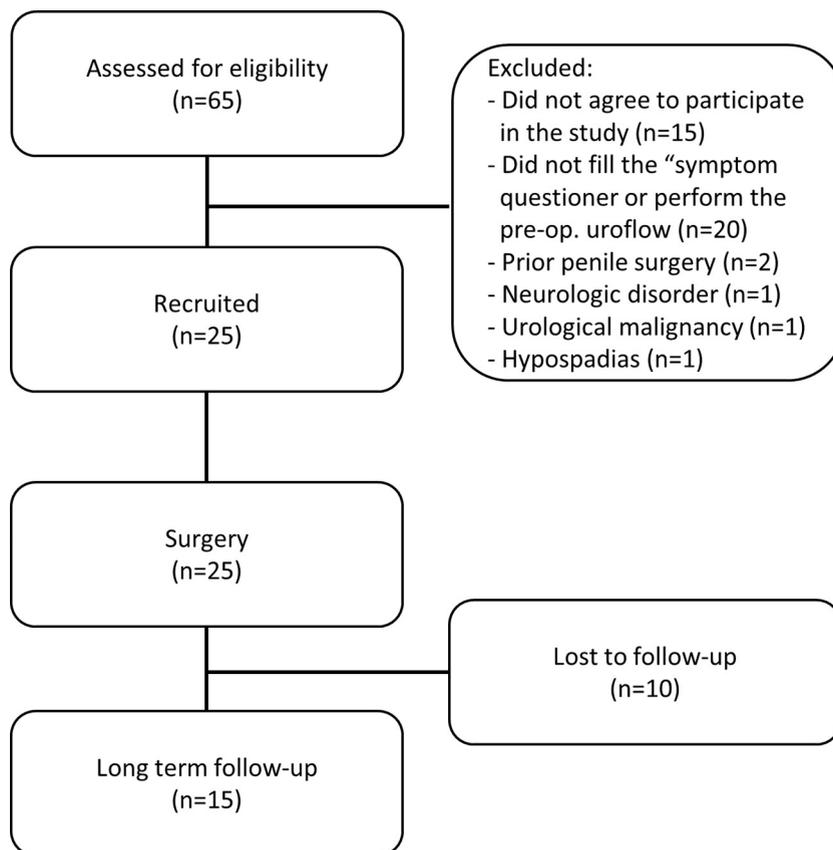
Figure 1. Trial profile shows participant flow through each stage of trial.

flow pattern at long-term follow-up. PVR was 35.6 mL, 15 mL (P = .076) and 0 mL (P = .0012) before surgery, 1 month after surgery and at long-term follow-up, respectively. The improvement in parameters that were defined as the endpoint of the study was consistent at short and long-term follow-up. Postvoid residual volume did not show a significant improvement at short-term follow-up but was significantly lower at long-term follow-up.

No surgical complications or need for readmission were recorded.

DISCUSSION

Meatal stenosis is a common finding in pediatric urological practice, with varying presenting symptoms in toilet trained boys ranging from no symptoms to dysuria and even bladder outlet obstruction.[1,10,11] In this prospective study in which we assessed clinical long-term outcomes and uroflowmetry parameters after meatotomy with a mean follow-up of nearly 4 years, there was a predominate resolution of both storage as well as voiding symptoms (Table 1) and improvement of meatal stenosis and urinary

Table 1. Patient symptoms and meatal appearance prior to, 1 month after and at late follow-up to surgical intervention

	Before Surgery	One Month After Surgery	P Value	Late Follow-up	P Value
Symptoms (number of patients)					
Deflected stream	13	0	.0001	2	.0001
Thin stream	9	0	.0007	0	.0007
Extended urination	2	0	.48	1	1
Storage symptoms	3	0	.22	0	.22
Enuresis	2	0	.48	0	.48
Sitting to urinate	1	0	1	0	1
Long distance stream	2	0	.48	1	1
Pain	3	0	.22	0	.22
Dysuria	2	0	.48	0	.48
Meatal appearance (number of patients)					
Pinpoint	14	0	.0001	0	.0001
Mild stenosis	1	4	.33	3	.6
Open	0	11	.0002	12	.0001

Table 2. Patient uroflowmetry parameters and flow pattern prior to, 1 month after, and at late follow-up to surgical intervention

	Before Surgery	One Month After Surgery	P Value	Late Follow-up	P Value
Uroflowmetry parameters					
Voided volume ± SD (mL)	156 ± 79	187 ± 128	.43	105 ± 84	.09
Qmax ± SD (mL/sec)	11.5 ± 6	15.3 ± 4.4	.06	12.6 ± 4	.56
Normal Qmax ICCS (Nu. Patients)	5	11	.06	12	.02
Qavg ± SD (mL/sec)	7.8 ± 4.4	10 ± 2.6	.1	7 ± 2.4	.54
Voiding time ± SD (sec)	21 ± 13.1	19 ± 15.6	.7	16 ± 12.7	.3
Post void residual ± SD (mL)	35.6 ± 38.1	15 ± 20.8	.07	0	.0012
Flow pattern (Number of patients)					
Flat	8	1	.005	2	.02
Bell shaped	6	14	.005	12	.06
Staccato	0	0	1	1	1

ICCS, International Children's Continence Society; Qmax, maximal urinary flow; Qavg, average urinary flow; SD, Standard deviation.

flow curves. Different surgical techniques have been described for the correction of the stenotic meatus,[4,12,13] with symptomatic improvement in most patients and low rates of recurrence and of reoperation. Surgical outcomes have been estimated by questioning the patient and the parents as well as physician witnessed voiding. Using uroflowmetry studies for the assessment has been described in a retrospective study of 22 symptomatic meatal stenosis patients after meatoplasty.[6] Similarly to our study, the most common symptom was deflected urinary stream in 20 patients, as well as frequency, dysuria and UTI in 9, 6 and 2 patients, respectively. Assessing the relevance of Qmax and Qavg has been questioned in the pediatric population due to relative small bladder size and voiding volume. In order to better assess these parameters we used the calculated ICCS Qmax defining normal if $Qmax^2 >$ voided volume.[8] Number of patients with normal Qmax increased significantly from 5 to 11 and 12 patients before surgery, 1 month and long-term checkup after surgery, respectively.

Flow patterns after meatotomy significantly improved, with flat pattern changing to normal pattern in 8 patients. Such descriptions might be limited due to interobserver variability. Franco et al[9] showed in their study that by
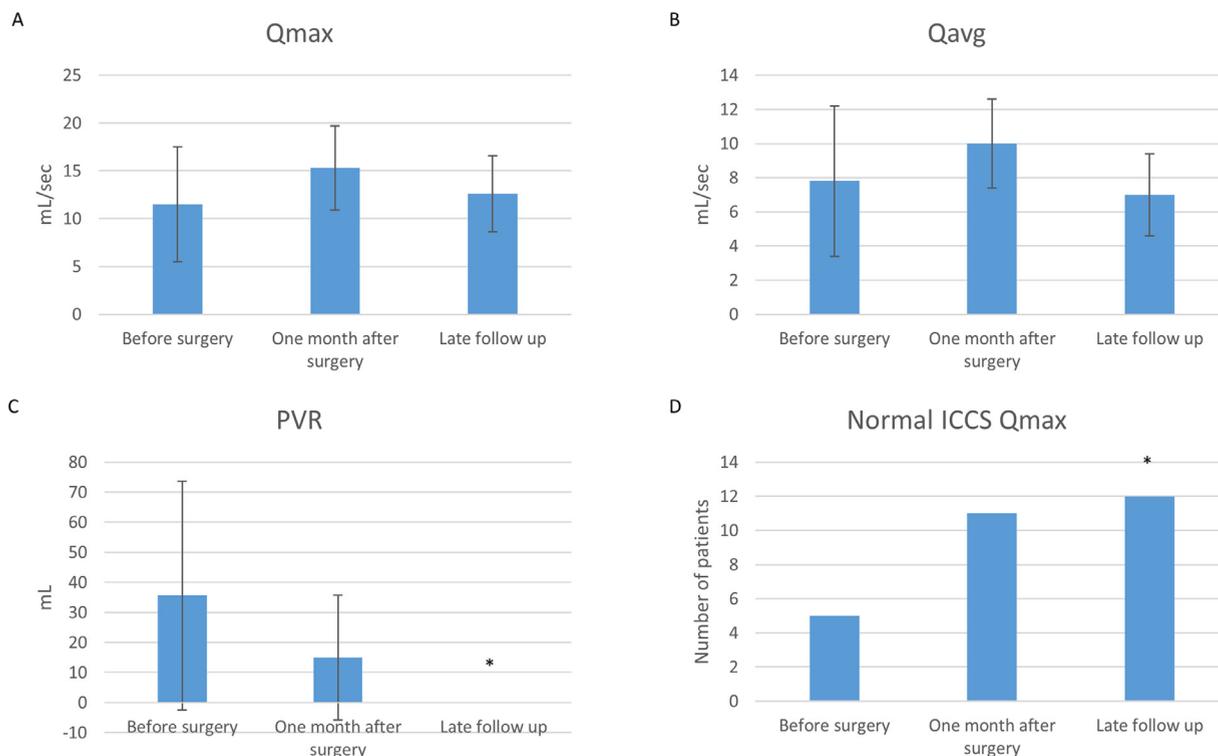

Figure 2. (A) Mean Qmax before surgery, 1 month after surgery and at long-term follow-up; (B) Mean Q average; (C) Postvoid residual volume; (D) Normal ICCS Qmax.

    Graphs A-C represented as mean ± standard deviation (SD). Graph D represents number of patients.

    *Represents clinically significant change from baseline (*P* <.05).

correcting for voided volume and creating a FI, an objective parameter of flow pattern can be achieved, thus removing subjectivity from urine flow analysis. FI is calculated either for Qmax or Qavg (e.g. FI = actual Qavg/estimated Qavg) thus directly comparing two separate flows in a single patient. A Canadian study, evaluating cost effectiveness of uroflowmetry pediatric urology patients, reported in a subgroup of 21 symptomatic meatal stenosis patients that uroflowmetry supported decision making in favor of surgery in 41%,[14] although exact information on decision process was not elaborated.

Similar to our results, VanderBrink et al demonstrated an improved Qmax, reduced PVR and shorter voiding times with a mean follow-up of 12 months.[6] The authors concluded that uroflowmetry is a possible alternative method in assessing postsurgical outcome with improved diagnosis of recurrence or persistent voiding disorders. However, as noted in MacNeily's editorial comment of the article,[15] lack of postsurgical uroflowmetry parameters improvement does not necessarily correlate with continuing clinical symptoms. In such a case, performing an uroflowmetry in an asymptomatic patient might seem unnecessary, especially with available assessment in the form of physical examination and witnessed voiding.

The sustainable clinical improvement for a period of over 3 years suggests that a single 1 month postoperative follow-up is sufficient after meatotomy. Our results reinforce the principle that meatal stenosis is a de-facto true "urethral stricture" and should be treated after adequate diagnosis. Whereas in urethral stricture severity is estimated using either cystoscopy or urethrography,[16] in meatal stenosis due to the superficial location of the stricture, physical examination might suffice.

In this study the recruitment rate was low and the dropout rate was high. It is important to acknowledge that performing uroflowmetry is cumbersome in young individuals. Before surgery the drop-out rate was considerable mainly due to inability to perform the uroflow despite being fully toilet trained. After surgery 10 cases did not complete the follow-up, predominantly because the children had marked improvement of symptoms, as observed one month after surgery, and the parents considered the uroflow to be futile and time consuming.

Repeat uroflowmetry might have provided more accurate results, especially in the long-term follow-up period. On the other hand it is plausible to believe that the compliance to our study would have decreased even further. This together with the range of long-term follow-up after surgery denotes the difficulty of performing follow-up in the pediatric population.

Performing a more objective urodynamic study was considered inappropriate by the local IRB committee considering the invasive nature of the procedure. A 7F catheter cannot be inserted preoperatively due to meatal stenosis therefore a base line urodynamic test cannot be acquired before surgery.

To our knowledge this is the first long-term prospective study evaluating uroflowmetry parameters before and after surgery in primary meatal stenosis patients. Another strength of the study is the long-term follow-up of objective and subjective assessment after meatotomy, performed using symptom evaluation questionnaires, and physical examination.

CONCLUSION

Symptom evaluation and physical examination should be the hallmark assessing children with meatal stenosis. Meatotomy is a simple, safe and effective procedure that offers durable relief of symptoms such that clinical improvement 1 month after surgery negates the need for long-term follow-up. Although some uroflowmetry parameters have improved after surgery, performing such study is unnecessary in evaluating meatal stenosis.

References

1. Joudi M, Fathi M, Hiradfar M. Incidence of asymptomatic meatal stenosis in children following neonatal circumcision. *J Pediatr Urol*. 2011;7:526–528.
2. Van Howe RS. Incidence of meatal stenosis following neonatal circumcision in a primary care setting. *Clin Pediatr (Phila)*. 2006;45:49–54.
3. El-Kasaby A, El-Baz M, El-Zayat T. Eversion meatoplasty in management of urethral meatal stenosis. *Int Urol Nephrol*. 1996;28:229–233.
4. Godley SP, Sturm RM, Durbin-Johnson B, Kurzrock EA. Meatal stenosis: a retrospective analysis of over 4000 patients. *J Pediatr Urol*. 2015;11:38.e1–38.e6.
5. Varda BK, Logvinenko T, Bauer S, Cilento B, Richard NY, Nelson CP. Minor procedure, major impact: patient-reported outcomes following urethral meatotomy. *J Pediatr Urol*. 2018;14:165.e1–165.e5.
6. VanderBrink BA, Gitlin J, Palmer LS. Uroflowmetry parameters before and after meatoplasty for primary symptomatic meatal stenosis in children. *J Urol*. 2008;179:2403–2406.
7. Ben Haim Y, LY, Gofrit O, et al. *Israeli Urological Association annual conference*. Eilat.
8. Austin PF, Bauer SB, Bower W, et al. The standardization of terminology of lower urinary tract function in children and adolescents: update report from the Standardization Committee of the International Children's Continence Society. *J Urol*. 2014;191. 1863-5.e13.
9. Franco I, Yang SD, Chang SJ, Nussenblatt B, Franco JA. A quantitative approach to the interpretation of uroflowmetry in children. *Neurourol Urodyn*. 2016;35:836–846.
10. Persad R, Sharma S, McTavish J, Imber C, Mouriquand P. Clinical presentation and pathophysiology of meatal stenosis following circumcision. *BJU Int*. 1995;75:91–93.
11. Upadhyay V, Hammodat H, Pease P. Post circumcision meatal stenosis: 12 years' experience. *N Z Med J*. 1998;111:57–58.
12. Wang M-H. Surgical management of meatal stenosis with meatoplasty. *J Visualized Exp: JoVE* 2010;(45).
13. Cubillos J, George A, Gitlin J, Palmer LS. Tailored sutureless meatoplasty: a new technique for correcting meatal stenosis. *J Pediatr Urol*. 2012;8:92–96.
14. Alyami F, Farhat W, Figueroa VH, Romao RL. Utility and cost-effectiveness of uroflowmetry in a busy pediatric urology practice. *Can Urol Assoc J*. 2014;8:E615.
15. MacNeily AE. Editorial Comment. *J Urol*. 2008;179:2406.
16. Wessells H, Angermeier KW, Elliott S, et al. Male urethral stricture: American Urological Association Guideline. *J Urol*. 2017;197:182–190.