Pediatric cystoscopy of male urethral strictures: an accurate and useful preoperative surgical decision making tool

Gregory P. Murphy, MD,[1] Kushan D. Radadia, MD,[1] Jonathan Weese, MD,[1] Cooper R. Benson, MD,[2] Niraj Badhiwala, MD,[1] Alethea Paradis, MD,[1] Joel Vetter, MD,[1] Steven B. Brandes, MD[2]

[1]Washington University School of Medicine, St. Louis, Missouri, USA
[2]Columbia University School of Medicine, New York, New York, USA

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Introduction: *To evaluate flexible pediatric cystoscopy (FPC) as an adjunctive procedure to retrograde urethrography (RUG) and voiding cystourethrography (VCUG) in the preoperative setting for male urethral strictures. Since imaging interpretation of stricture length and caliber can be difficult at times, we sought to evaluate diagnostic utility of FPC to predict reconstructive surgery.*

Materials and methods: *Reconstructive urology databases at Washington University and Columbia University were queried from 2010-2017. A total of 185 anterior urethroplasty patients met inclusion criteria. All surgeries were performed by a single surgeon. There were 102 patients that underwent preoperative FPC (7.5 Fr in diameter). Surgical urethroplasty techniques employed were: ventral or dorsal onlay buccal mucosa graft, fasciocutaneous penile skin flap, excision and primary anastomosis or augmented anastomotic. We analyzed the RUG, VCUG, FPC, and intraoperative details of the urethral strictures by univariate and multivariate statistics.*

Results: *Mean patient age was 47.2 (+/-16.5) years. Of the patients who underwent FPC, 42.2% were narrower than the FPC, and 57.8% were wider. Intraoperative stricture length better correlated with FPC findings compared to RUG/ VCUG ($r = 0.834$ versus $r = 0.766$) ($p < 0.001$). Moreover, inability to pass the FPC through the stricture correlated with the need to perform urethral stricture excision or complete reconstruction of the urethral plate ($p = 0.005$), rather than onlay urethroplasty.*

Conclusion: *Preoperative FPC is a useful adjunctive tool in the evaluation of urethral strictures. FPC facilitates stricture assessment by accurately correlating with intraoperative stricture length and predicting the need to excise or graft during reconstruction.*

Key Words: flexible pediatric cystoscopy, decision making tool, reconstructive

Introduction

Preoperative invasive evaluation of male urethral strictures can include a variety of studies such as cystoscopy, urethrography, ultrasound and in some cases three-dimensional imaging.[1] While preoperative cystoscopy is excellent for diagnosing the distal margin of a stricture, it lacks the ability to determine stricture length.[2] The typical adult flexible cystoscope is 16 Fr in diameter from Olympus or Storz and therefore cannot pass through a clinically significant stricture. A properly performed retrograde urethrogram (RUG) and voiding cystourethrogram (VCUG) are the gold standard imaging techniques for reliably evaluating male urethral strictures, as they can determine stricture length and location.[3] However, urethrography is not without limitations as it has been shown to underestimate stricture length, particularly in the bulbar urethra.[3,4] Urethrography can be difficult to interpret in many cases due to poor radiologic technique or difficult patient anatomy.[4] In some patients, a VCUG cannot be performed because of a "shy" bladder or difficulty in passing a catheter. Without a VCUG, the ability to evaluate the proximal aspect of an anterior stricture, the posterior urethra or the bladder are all severely weakened. Many urologists have limited exposure to stricture patients making it challenging to interpret results of urethrography.[5]

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Address correspondence to Dr. Kushan D. Radadia, Washington University School of Medicine, 4960 Children's Place, 2 Wohl Clinic, Suite 216, St. Louis MO 63110 USA

Trans-perineal ultrasound has been shown to have increased accuracy in determining stricture length when compared to RUG and VCUG.[6] However, trans-perineal ultrasound is not without its own drawbacks as it is difficult to perform in the clinic and time consuming.[7]

Flexible pediatric cystoscopy (FPC) is an adjunctive preoperative procedure that can be easily performed in the office. The typical flexible pediatric cystoscope, measuring 7.5 Fr, is able to traverse many non-obliterative strictures and thus the full extent of the anterior urethra. FPC can provide valuable additional information, especially in cases when the urethrography findings are unclear.[7] We sought to evaluate the accuracy and utility of FPC in the preoperative assessment of urethral strictures. Our hypothesis was that FPC can accurately determine stricture length and is a useful adjunct in facilitating preoperative decision making, and thus predictive of intraoperative urethral reconstruction technique.

Materials and methods

The prospectively maintained and IRB approved reconstructive urology databases at our two major referral centers for urethral surgery were queried from 2010-2017. Patients who had a urethral stricture diagnosed with a RUG/VCUG at the two institutions were included in the study. Patients with concomitant urethral fistula repair were excluded. A total of 185 patients met inclusion criteria with 102 undergoing preoperative FPC (Karl Storz, 7.5 Fr caliber and 26 cm in length). Eighty-three non-FPC patients were used as controls. All urethroplasties were performed by a single surgeon. Surgical techniques employed were ventral or dorsal onlay buccal mucosa grafting (BMG), BMG inlay (Asopa), fasciocutaneous penile skin flap, excision and primary anastomosis (EPA), augmented anastomotic (EPA + BMG). We broadly grouped these surgical techniques utilized into two categories: 1) stricture excision 2) non-excision (urethral augmentation), based on the adequacy of the urethral plate upon urethrotomy. The urethral plate was carefully measured intraoperatively as well as the length of the stricture. If a BMG or fasciocutaneous penile skin flap were performed in patients with an adequate urethral plate, they were not designated as excisional. An excisional urethroplasty was either an EPA or augmented anastomosis. The urethral plate was excised when it was < 5 mm in width, as noted at the time of the open urethrotomy.

Analysis of preoperative urethral stricture anatomical characteristics were based on RUG, VCUG, and FPC including stricture length, location and ability of the FPC to pass through the stricture (stricture > 8 Fr in diameter). RUG/VCUG stricture length was based on radiology report. FPC stricture length was measured from proximal to distal end of the stricture using visual estimate of normal caliber urethral lumen or greater than 16 Fr. RUG and VCUG were retrospectively graded according to their quality as on a scale from 0 to 3 (0 - no image, 1 - suboptimal, 2 - adequate, 3 - excellent), based on image quality and patient positioning. Grading was performed by two expert readers. The RUG/ VCUGs of the non –FPC evaluated patients were also graded, in order to serve as a control. Intraoperative findings were recorded including stricture length and the reconstructive technique performed. Intraoperative stricture length was measured with a ruler in the operating room after stricturotomy and correlated to graft/flap length.

Pearson's correlation coefficient was used to examine the correlation between the FPC stricture length, the RUG stricture length, and operative stricture length. Chi Square tests of independence and Mann-Whitney U-Tests were used to test for associations for categorical and numerical variables of interest. Two linear regression models were fit with operative stricture length as the dependent variable. RUG stricture length was used in one model as the independent variable and pediatric scope stricture length in the other model. Akaike Information Criteria (AIC) was then used to compare which model best fit the data. Statistical significance was set at $p < 0.05$ and all statistical test were two-sided. All statistics were performed in R v3.3.1.[8]

Results

Patient demographics are detailed in Table 1. Mean age was 47.2 (+/- 16.5) years. Stricture location was classified as 21.8% penile, 64.2% bulbar, 12.1% membranous and 1.8% pan-urethral. The mean stricture length from RUG/VCUG was 3.70 cm (+/- 2.93), the mean stricture length based on FPC was 3.78 cm (+/- 3.30) while the mean operative stricture length was 4.98 cm (+/- 2.80). Of the 102 patients who had attempted FPC, 70 were done at Washington University while 32 were performed at Columbia University. In 42.2% of the patients, the strictures were narrower than 7.5 Fr and the FPC was unable to pass to the proximal end of the stricture. In 57.8% of the patients, the strictures were wider than the FPC (> 7.5 Fr), and thus allowing for measurement of stricture length.

FPC determined stricture length accurately correlated with the gold standard RUG/VCUG preoperative estimation of stricture length ($r = 0.932$, $p < 0.001$). However, FPC determinations better correlated with intraoperative stricture length compared to RUG/ VCUG ($r = 0.835$ versus $r = 0.772$), Table 2. Using AIC to model FPC versus RUG/VCUG, the FPC AIC of 160.1

TABLE 1. **Patient demographics**

	Mean (+/-SD) or N (%)
Institute	
Washington University	122 (65.9%)
Columbia University	63 (34.1%)
Age	47.2 (+/-16.5)
Race (n = 165)	
White	133 (80.6%)
Black	16 (9.7%)
Other	16 (9.7%)
AUA Symptom Score (n = 131)	18.3 (+/-9.2)
Stricture location (n = 165)	
Penile	36 (21.8%)
Bulbar	106 (64.2%)
Membranous	20 (12.1%)
Panurethral	3 (1.8%)
Stricture etiology (n = 122)	
Hypospadias	8 (6.6%)
Iatrogenic	15 (12.3%)
Inflammatory/infectious	11 (9.0%)
Trauma	21 (17.2%)
Idiopathic	67 (54.9%)
Stricture length (cm)	
RUG/VCUG	3.7 (+/- 2.93)
FPC	3.78 (+/- 3.3)
Operative	4.98 (+/- 2.8)
Pediatric scope attempted	
No	83 (44.9%)
Yes	102 (55.1%)
Surgery type	
Augmented anastomotic	26 (14.1%)
Excision & primary anastomosis	33 (17.8%)
Fasciocutaneous flap	21 (11.4%)
Buccal mucosal graft	105 (56.8%)

AUA = American Urological Association; RUG = retrograde urethrogram; VCUG = voiding cystourethrogram; FPC = flexible pediatric cystoscopy

was significantly better than the RUG/VCUG of 171.4. Figure 1 shows the Pearson correlation with best fit line comparing these three tests. The figures demonstrate that FPC best correlates with actual intraoperative determined stricture length.

When FPC was performed, 46.1% of RUGs and 59.8% of VCUGs were graded 0-2 or less than excellent. When compared to the control cohort of non-FPC evaluated stricture patients, RUG and VCUG grading was not statistically different (p = 0.8 and p = 0.9).

The inability to pass the FPC through the stricture correlated with higher post void residual (PVR) and excisional intraoperative repair (EPA or augmented anastomotic), Table 3. In contrast, when the FPC was able to pass demonstrating a wider caliber stricture, a graft or flap was more likely to be performed (p = 0.005). No difference was seen in patient age or AUA symptom score (AUA SS).

Discussion

The current standard of care for evaluating a urethral stricture is a combined RUG and VCUG, and supplemented where necessary by cystoscopy. Such cystoscopy is typically an adult flexible or rigid cystoscope. Often a large caliber cystoscopy cannot pass beyond the distal aspect of a significant urethral stricture. Thus, many urethral surgeons define a clinically significant stricture as one that is narrower than an adult 16 Fr flexible cystoscope diameter.[3] A properly performed urethrography, in the correct oblique position, can produce accurate and reliable assessment of an anterior urethral stricture. However, proper patient positioning for imaging can be prevented by patient physical disability or deformity.[4] While urologists may perform urethrography in high-volume academic centers, it is not commonly performed in the community.[5] Such limited exposure to urethrography can make it challenging for urologists and radiologists to interpret results in certain settings.[5] Even when properly performed, a recent survey of urology and radiology residents noted they mostly possess poor urethrography interpretive skills.[9] In these settings, pediatric flexible cystoscopy can be used as an adjunctive procedure to evaluate a urethral stricture. FPC is familiar to urologists and can be useful in a novice urethral surgeon who has limited experience urethrography studies.

The use of flexible pediatric cystoscopy in evaluating stricture length and location was originally introduced

TABLE 2. **Pearson correlation of stricture length**

Correlation of stricture length	**Pearson correlation**	**p value**
FPC correlation with RUG	0.931	< 0.001
FPC correlation with operative stricture length	0.835	< 0.001
RUG correlation with operative stricture length	0.772	< 0.001

FPC = flexible pediatric cystoscopy
RUG = retrograde urethrogram

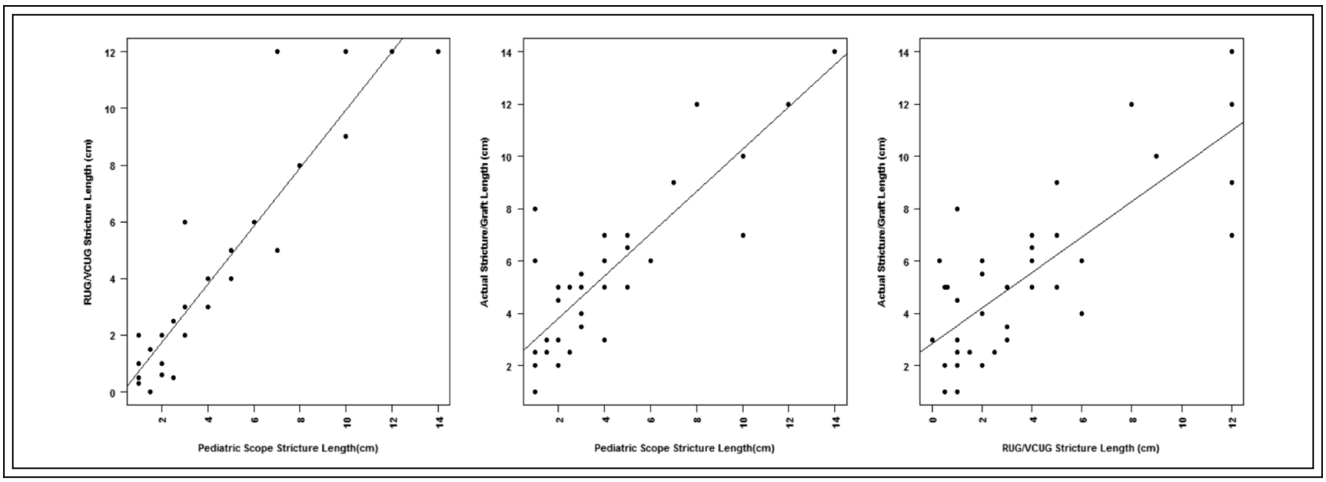

Figure 1. Pearson correlation comparing stricture length by three modalities.

by Figueroa and Honeig in 2004 in their pilot study of 24 patients in which all patients had urethral calibers >7.5 Fr.[10] They concluded that FPC can be helpful in cases where urethrography quality images are lacking and can provide more information than an adult cystoscope, due to its ability to navigate narrower strictures to proximal bulbar/membranous urethra. Serving mainly as a feasibility study, they suggested further studies be done to determine cost-effectiveness and ability to tailor therapy appropriately when comparing FPC to RUG/VCUG. Our study similarly found that preoperative FPC can serve as an adjunctive tool in the anatomic evaluation of anterior urethral strictures. In our study, FPC was performed in both high and low quality RUG/VCUGs to aid patient accrual. FPC can be the most useful in the setting of a low quality imaging when the proximal extent of the stricture or the posterior urethra is poorly imaged.

TABLE 3. **Comparison of surgery based on flexible pediatric cystoscopy findings**

Variable	Narrower (43)	Wider (59)	p value
Age			0.069
Mean	42.7	49.4	
Standard deviation	14.3	14.9	
AUA Symptom Score			0.861
Mean	21.5	20.6	
Standard deviation	8.5	9.2	
Missing	5	4	
Post void residual			0.043
Mean	108.8	48.1	
Standard deviation	134.2	75.3	
Missing	20	15	
Surgery type			0.007
Augmented anastomotic (15)	25.6%	6.8%	
Excision & primary anastomosis (17)	20.9%	13.6%	
Flap (11)	14.0%	8.5%	
Buccal mucosal graft (59)	39.5%	71.2%	
Excision			0.005
No (70)	53.5%	79.7%	
Yes (32)	46.5%	20.3%	

AUA = American Urological Association

Our results demonstrated that FPC facilitates stricture assessment and correlates with intraoperative stricture length more than conventional urethrography ($r = 0.835$ versus $r = 0.772$, $p < 0.001$). An AIC model was used to compare FPC to RUG/VCUG to intraoperative stricture length assessment and found the AIC for FPC to be lower and with a difference greater than 10. AIC modeling studies show that a difference of more than 10 units is indicative of a clinically significant improvement in testing.[11] While the results show that FPC is more accurate and reliable than conventional urethrography at assessing stricture length, we still advocate for the use of gold standard urethrography. FPC can be used as an adjunctive tool to urethrography. In the setting of poor imaging, FPC can aid a urologist in assessing

the urethral stricture under direct visualization. Other techniques such as a urethral catheter can be used to calibrate the urethra. However, this can traumatize a stricture and delay treatment. FPC allows a urologist to evaluate a stricture's caliber with minimal trauma and assess its length.

The purpose of an accurate and reliable, preoperative evaluation for a male anterior urethral stricture is to facilitate preoperative decision making, and also to determine the best reconstruction surgical option.[12] In order to formulate a proper surgical plan, an accurate study is essential to determine stricture presence, number, location, length, and degree (urethral plate health and caliber).[13] It can be difficult to appreciate the health of the urethral plate with urethrography alone.[14] While an obliterated urethral plate requires excision or complete reconstruction, FPC can be helpful in evaluating narrow urethral plates for the feasibility of augmentation urethroplasty by BMG onlay or penile skin flap.[13] The results showed a higher rate of performing an excision of the stricture (EPA or augmented anastomotic) when the FPC was unable to pass proximal to the stricture. In contrast, when the FPC was able to pass proximally (demonstrating a wider caliber stricture), a graft or flap (urethral augmentation) was more likely to be performed ($p = 0.005$). When performing an anterior urethroplasty, the urethral plate is evaluated to decide on excision or augmentation. Plates < 5 mm were typically excised while plates > 5 mm were augmented. The value of performing FPC is that a urologist can potentially predict preoperatively the type of reconstruction that will need to be done intraoperatively. Thus, by using FPC preoperatively, a urologist may be less likely to alter the surgical plan during surgery. The additional benefit of this preoperative assessment can help with patient counseling in explaining the procedure and any risks or potential complications with the procedure. Furthermore, not having to change the surgical plan may lead to faster operative time and potentially lower complication rates.

Several limitations were noted in this study. First, flexible cystoscopy was not performed in all patients suggesting a potential selection bias. FPC was performed in only 102 of a possible 185 urethroplasty patients. FPC was performed not only when urethrography imaging was difficult to interpret but to also to aid with patient accrual. No statistically significant difference was found in grading of RUG/VCUG between the 102 FPC patients and the 83 non FPC patients. Another limitation is the retrospective nature of the study and its lack of blinding. Knowing the results of the FPC could potentially bias the operation for or against excision. Lastly, despite the fact that the FPC may sometimes pass through a stricture, 20.3% of the time, excisional urethroplasty was still necessary which may be due to the stricture contracting further after FPC in the office.

While FPC should not replace urethrography, it is a helpful adjunctive tool to facilitate accurate measurement of stricture length and urethral plate size and aid in preoperative in surgical decision making. It is most helpful when urethrography is confusing or unclear and can potentially decrease the need to alter surgical plan intra-operatively.

Conclusion

FPC is a useful adjunctive tool to the gold standard urethrography in evaluating a urethral stricture. It correlates more with intraoperative stricture length more than urethrography alone and can predict the type of urethroplasty needed. FPC should be used in settings when quality of urethrography is poor. □

References

1. Wessells H, Angermeier KW, Elliott S et al. Male urethral stricture: American Urological Association guideline. *J Urol* 2017; 197(1):182-190.
2. Angermeier KW, Rourke KF et al. SIU/ICUD consultation on urethral strictures: evaluation and follow-up. *Urology* 2014;83 (3 Suppl):S8-S17.
3. Gallentine ML, Morey AF. Imaging of the male urethra for stricture disease. *Urol Clin North Am* 2002;29(2):361-372.
4. Morey AF, McAninch JW. Sonographic staging of anterior urethral strictures. *J Urol* 2000;163(4):1070-1075.
5. Flanagan JC, Batz R, Nordeck SM et al. Urethrography for assessment of the adult male urethra: radioGraphics fundamentals online presentation. *Radiographics* 2018;38(3):831-832.
6. Morey AF, McAninch JW. Role of preoperative sonourethrography in bulbar urethral reconstruction. *J Urol* 1997;158(4):1376-1379.
7. Morey AF, McAninch JW. Ultrasound evaluation of the male urethra for assessment of urethral stricture. *J Clin Ultrasound* 1996;24(8):473-479.
8. R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/
9. Eswara JR, Song JB, Chang AJ et al. Urethrography interpretation skills of urology and radiology residents at tertiary care medical centers. *Urology* 2014;83(6):1239-1242.
10. Figueroa JC, Hoenig DM. Use of 7.5F flexible pediatric cystoscope in the staging and management of urethral stricture disease. *J Endourol* 2004;18(1):119-121.
11. Akaike Hirotugu. (1975). A new look at the statistical model identification. *IEEE Transactions on Automatic Control* 1975;19(6): 716-723.
12. Mangera A, Patterson JM, Chapple CR. A systematic review of graft augmentation urethroplasty techniques for the treatment of anterior urethral strictures. *Eur Urol* 2011;59(5):797-814.
13. Joshi P, Kaya C2, Kulkarni S. Approach to bulbar urethral strictures: Which technique and when? *Turk J Urol* 2016;42(2):53-59.
14. Theisen KM, Kadow BT, Rusilko PJ. Three-dimensional imaging of urethral stricture disease and urethral pathology for operative planning. *Curr Urol Rep* 2016;17(8):54.