

The evolution of urethral stricture and urethroplasty practice over 15 years: A single-center, single-surgeon 1319 urethroplasty analysisDylan T. Hoare¹, R. Christopher Doiron^{1,2}, Keith F. Rourke¹¹Division of Urology, Department of Surgery, University of Alberta, Edmonton, AB, Canada; ²Department of Urology, Queen's University, Kingston, ON, Canada

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Abstract

Introduction: The management of urethral stricture has evolved over the last several decades. We sought to analyze urethral stricture and urethroplasty trends at a tertiary referral center over a 15-year period.

Methods: Patients undergoing urethroplasty by a single surgeon from August 2003 to July 2018 were analyzed. Patient demographics, urethroplasty techniques, and outcomes were collected in a prospectively maintained database and were categorized into three five-year tertiles based on date of surgery. These tertiles were subsequently retrospectively analyzed for trends and changes in practice.

Results: A total of 1319 urethroplasties were completed over the study period. During the first five years (T1), 299

Key Messages

- Urethroplasty practice has evolved over the last 15-years likely in response to urological society guidelines, innovation in surgical technique and locoregional referral patterns.
- With time urethroplasty volume increased along with changes in patient demographics, stricture etiology and complexity.
- In the last five-years, stricture length decreased along with reduction in the number of endoscopic procedures performed prior to referral with a concurrent increase in urethroplasty success.
- There has been a significant trend toward wide-spread adoption of single-stage urethroplasty with buccal mucosa at the expense of staged and penile fasciocutaneous flap reconstruction.

urethroplasties were performed, with 431 and 589 performed in T2 and T3 respectively. Mean overall patient age was 46.8 years, which increased significantly over time ($p < 0.001$). Idiopathic strictures were most common ($n = 516$, 39.1%) and unchanged over time, while proportionately radiation-induced strictures increased ($n = 9$, 3.0% [T1], $n = 22$, 5.1% [T2], $n = 51$, 8.7% [T3]; $p = 0.001$) as did iatrogenic and lichen sclerosus strictures. Mean stricture length (4.7 cm [T1], 4.8 cm [T2], 4.0 cm [T3]; $p < 0.001$) and the mean number of prior endoscopic procedures (3.4 [T1], 3.9 [T2], and 2.5 [T3]; $p < 0.001$) decreased over time. Single-stage urethroplasty with buccal mucosa was the most common technique performed ($n = 656$, 49.7%) that increased in prevalence ($p = 0.009$), while both flap and staged techniques decreased ($p = 0.008$, $p = 0.004$, respectively). Overall success rate was 90.1% ($n = 1106$), which improved significantly with time ($n = 248$, 86.7% [T1], $n = 359$, 90.0% [T2], $n = 499$, 93.4% [T3]; $p = 0.001$).

Conclusions: We observed that patients and treatment of urethral stricture evolved over 15 years in practice with an increase in patient age, radiation, and iatrogenic and lichen sclerosus strictures, while demonstrating a decrease in stricture length and the number of prior endoscopic procedures performed. An increased use of single-stage urethroplasty using buccal mucosa was observed, which may have contributed to an increase in urethroplasty success over time.

Introduction

The management of urethral strictures has evolved dramatically over the last several decades.¹ This has been related to several innovations in the field of reconstructive urology, particularly involving urethroplasty technique.² Historically, despite poor long-term success rates especially in the setting of recurrent stricture, patients were (and still are) most commonly managed endoscopically with either dilation or urethrotomy.³⁻⁵ While offering temporary improvement in lower urinary obstruction associated with urethral stricture, repeat endoscopic treatments can increase the complexity of urethral stricture and urethroplasty.⁶⁻⁷ Given the low rates of cure with repeat endoscopic treatment, multiple urological guidelines within the last 5-7 years have recommended urethroplasty after failure of endoscopic treatment or in patients at high risk of stricture recurrence.⁸⁻¹⁰ These recommendations in theory should result in a reduction in the use of repeat endoscopic treatment.^{4,5} In addition to advances in urethroplasty and guideline recommendations, urethroplasty practice can also be shaped by locoregional referral patterns. For example, healthcare in western Canada serves an estimated population of 11 million people in a geographic area of over 6.3 million km².¹¹ This region is 2 million km² larger than the European Union with 40 times less the population.¹² Historically,

only a small number of centres in this catchment routinely performed urethroplasty leading to a somewhat captive patient audience for urethroplasty while simultaneously providing a geographic barrier to referral. Nonetheless, reconstructive urology practice within this captive geographical zone may uniquely reflect changes in the evolution of urethroplasty practice and stricture management over time. We hypothesize that there will be a shift in patient demographics and stricture complexity as a reconstructive urology practices evolves and individual surgical experience grows. We aim to analyze trends in patient presentation and reconstructive practice in all patients undergoing urethroplasty at a single-centre over a 15-year period.

Methods

Patients undergoing urethroplasty by a single surgeon from August 2003 to May 2018 were included in this study. Patient demographics, clinical presentation, surgical procedure and outcomes data were collected in a prospectively maintained database. All patients undergoing urethroplasty during this time were eligible for study inclusion. No specific exclusion criteria were applied, and no outliers were omitted.

A retrospective analysis categorized patients into three, approximately five-year tertiles based on date of surgery (T1 = August 2003 – July 2008; T2 = August 2008 – May 2013; T3 = June 2013 – May 2018). These tertiles were compared and trends over time were analyzed with respect to the variables of patient age, stricture etiology, stricture length, number of prior endoscopic treatments, urethroplasty techniques and anatomic surgical success. The ability to pass a 16 Fr flexible videocystoscope at ~6-months post-operatively was defined as anatomic success. Patients were again evaluated at 18-months post-operatively, no evidence of recurrent stricture at this time-point defined overall urethroplasty success which was used for comparison between cohorts. Paired t-tests were performed when we sought to compare continuous variables to earlier cohorts (T1 and T2) to the surgeon's current state of practice (T3). Matched analysis of variance (ANOVA) was utilized when continuous variables were compared across all three cohorts simultaneously. Lastly, Chi-square analysis was used to compare categorical variables between tertiles. A pre-determined alpha value for significance was set at 0.05. Statistical analysis was performed using the IBM SPSS statistical software package.

Results

A total of 1319 urethroplasties were completed over the study period. During the first 5 years (T1), 299 urethroplasties were performed, while 431 and 589 were performed in T2 and T3 respectively (Figure 1A). Mean overall patient age was 46.8 years and this increased significantly over time ($p < 0.001$) (Figure 1B). Mean stricture length was 4.4cm and this was found to decrease over time [4.7cm (T1), 4.8cm (T2), 4.0cm (T3); $p < 0.001$]

(Figure 1C). with a previously failed endoscopic treatment alone (n=1172, 88.9%) while 249 patients (18.9%) had additionally undergone a prior open reconstruction. Overall, the mean number of prior endoscopic procedures decreased significantly over time [3.4 (T1), 3.9 (T2) and 2.5 (T3); $p<0.001$] (Figure 1D). Most patients presented with an idiopathic cause of their stricture (n=516, 39.1%) and this did not change over time (Table 1). Trauma was the second most common etiology (n=262, 19.9%), but decreased significantly over time ($p<0.001$). Radiation induced strictures significantly increased over time [n=9, 3.0% (T1), n=22, 5.1% (T2), n=51, 8.7% (T3); $p=0.001$] as did iatrogenic and lichen sclerosus-associated strictures. Regarding urethroplasty technique, single stage urethroplasty with buccal mucosa was most commonly performed (n=656, 49.7%) and increased in prevalence over time ($p=0.009$) (Table 2). Flap and staged techniques decreased over time ($p=0.008$, $p=0.004$, respectively). The remaining techniques did not vary. Finally, the overall success rate at 18-months was 90.1% (n=1106). This appeared to improve significantly with time [n=248, 86.7% (T1), n=359, 90.0% (T2), n=499, 93.4% (T3); $p=0.001$] (Figure 2).

Discussion

The evolution and refinement of urethroplasty over the last 15 years has been reflected in this analysis of trends in a single-centre, single-surgeon retrospective cohort study. Through establishing three discrete tertiles, we were able to portray interval improvements in urethroplasty success whilst simultaneously showing both expected and unexpected changes in stricture length, etiology and complexity.

Over the course of the study period, urethroplasty volume grew progressively. This may be related to the evolution of a tertiary referral centre where with experience and reputation, an increasing number of patients are referred for genitourinary reconstruction. Alternately, this trend could also represent a general shift in dedicated sub-specialization happening throughout the field of urology.¹³ Regardless, of the exact reason for the increase in urethroplasty volume, this trend mirrored a concurrent steady increase in anatomically defined surgical success. Overall success of urethroplasty over the 15-year period defined by a cystoscopic endpoint was 90.1%. Broadly reported success rates for the index stricture patient undergoing standard buccal mucosa graft urethroplasty have been estimated across multiple series to be at least 80%.^{8,9} In our centre, from the outset, this threshold has been exceeded across all urethroplasty subjects, increasing from 86.7% in the first five years to 93.4% in the most recent tertile. Urethroplasty competency has been estimated to occur at around 100 cases which seems plausible given that this threshold was surpassed in all five-year tertiles.¹⁴ However, even past this threshold, it is thought that the surgical learning curve of urethroplasty may continue to improve past 600 cases.¹⁵ In addition to surgical experience, the progressive improvement observed in our practice may be indicative of continued refinement of

surgical technique. One component of this refinement is the continued use and broadened application of single-stage buccal mucosal grafts even in the penile urethra.¹⁶ Both local tissue flaps and staged approaches have experienced a significant decline at our centre. This shift away from flaps and staged operations has likely been driven by similar-to-inferior success rates, higher cumulative post-operative morbidity, improved patient selection and patient preference.^{17,18}

Improved surgical success at our centre may have led to a widening of the referral base with a subsequent increase in urethroplasty volume or vice versa. Nonetheless, this increase in patient volume appears to be associated increasingly complex patients as manifested by an increase in treatment of older patients with more challenging stricture etiologies. In our study, patient age at the time of urethroplasty steadily increased across tertiles by an absolute total of nearly 6 years. Although age has not been shown to definitively impact urethroplasty success rates, it does bring with it potential increased comorbidities and greater peri-operative risk.^{19,20}

In terms of stricture etiology, idiopathic strictures remained the most common cause of stricture throughout the 15-year period but other etiologies such as lichen sclerosus, iatrogenesis and radiation increased in relative amounts. These etiologies are generally regarded as more challenging to treat. For example, radiation-associated urethral stenoses are commonly associated with a myriad of other genitourinary adverse events such as sphincteric weakness, pain, radiation cystitis, refractory lower urinary tract symptoms, fistulae and prostatic necrosis thereby contributing to greater surgical complexity.²¹ These intricacies are mirrored, albeit to a lesser extent, in iatrogenic and lichen sclerosus-associated patients which are commonly associated with urethroplasty failure and complexity.^{22,23} Over time, these older and more challenging patients have composed a greater proportion of the urethroplasty cohort at our centre.

Stricture length is interestingly, one component of stricture complexity that has decreased over time, changing from 4.7 cm to 4.0 cm. This potentially reflects the continued movement away from endoscopic management of strictures, particularly in the recurrent setting.⁸⁻¹⁰ The ICUD consultation of urethral stricture as well as both the AUA and CUA guidelines endorse that repeat endoscopic treatment may increase stricture complexity, urethroplasty complexity and the rate of stricture recurrence.⁶⁻¹⁰ A recent randomized study evaluating urethroplasty versus endoscopic urethrotomy in the recurrent setting found that although both interventions yield significantly improved symptoms, open repair has the more durable response and once again, requires less re-intervention.²⁴ In our findings, patients in the third most recent tertile underwent significantly fewer attempts at endoscopic management and as a result may have avoided iatrogenic increase in stricture length and complexity. This more contemporary trend has been observed elsewhere.⁵ Despite a decline in the number of prior endoscopic

treatments, the majority of patients still futilely undergo repeat endoscopic attempts prior to undergoing definitive urethroplasty. Possibly, although we are unable to prove this with our current results, the decrease in stricture length could also be accounted for by refinements in preoperative staging. Improved retrograde urethrography resolution and better incorporation of cystoscopic findings may lead to less overestimation of stricture length.²⁵

Despite the use of prospective data collection, our study methodology involved retrospective analysis, potentially introducing bias into our conclusions. Additionally, there may have been a selection bias influencing some of the findings if surgical judgement and decision making improved over the study period. This would result in demographic changes and improved outcomes independent of referral patterns. The decision to divide the cohorts into tertiles could also be viewed as an arbitrary threshold. Nevertheless, we believe these represent reasonable intervals to evaluate change and growth in one's practice. Despite the retrospective evaluation and the potential confounders this methodology may introduce, it is suitable given the prolonged and unique look this study provides into the maturation and evolution of a single-surgeon's practice.

Conclusions

The surgical treatment of urethral stricture has evolved over the last fifteen years and with it, so has the approach to treatment at our centre. Increases in patient age, radiation, lichen sclerosus and iatrogenic strictures have been observed. A decrease in stricture length, and a reduction in the number of endoscopic procedures performed prior to referral have also been seen. The increased preference for single-stage urethroplasty with buccal mucosal substitution was observed, likely resulting from the patient centered evolution of the technique and increasing surgeon's comfort with said modality.

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DRAFT

Figures and Tables

Figure 1. Bar charts depicting trends in (A) urethroplasty volume, (B) patient age, (C) stricture length, and (D) number of prior endoscopic treatments over the 15-year study period. (A) Number of urethroplasties performed per tertile with increase over the study period. (B) Patient age (in years) at the time of urethroplasty with significant differences between each tertile. (C) Stricture length (cm) per tertile with significant difference between the most recent and preceding 2 tertiles. (D) Number of prior endoscopic procedures (n) per tertile with significant differences between most recent and preceding 2 tertiles.

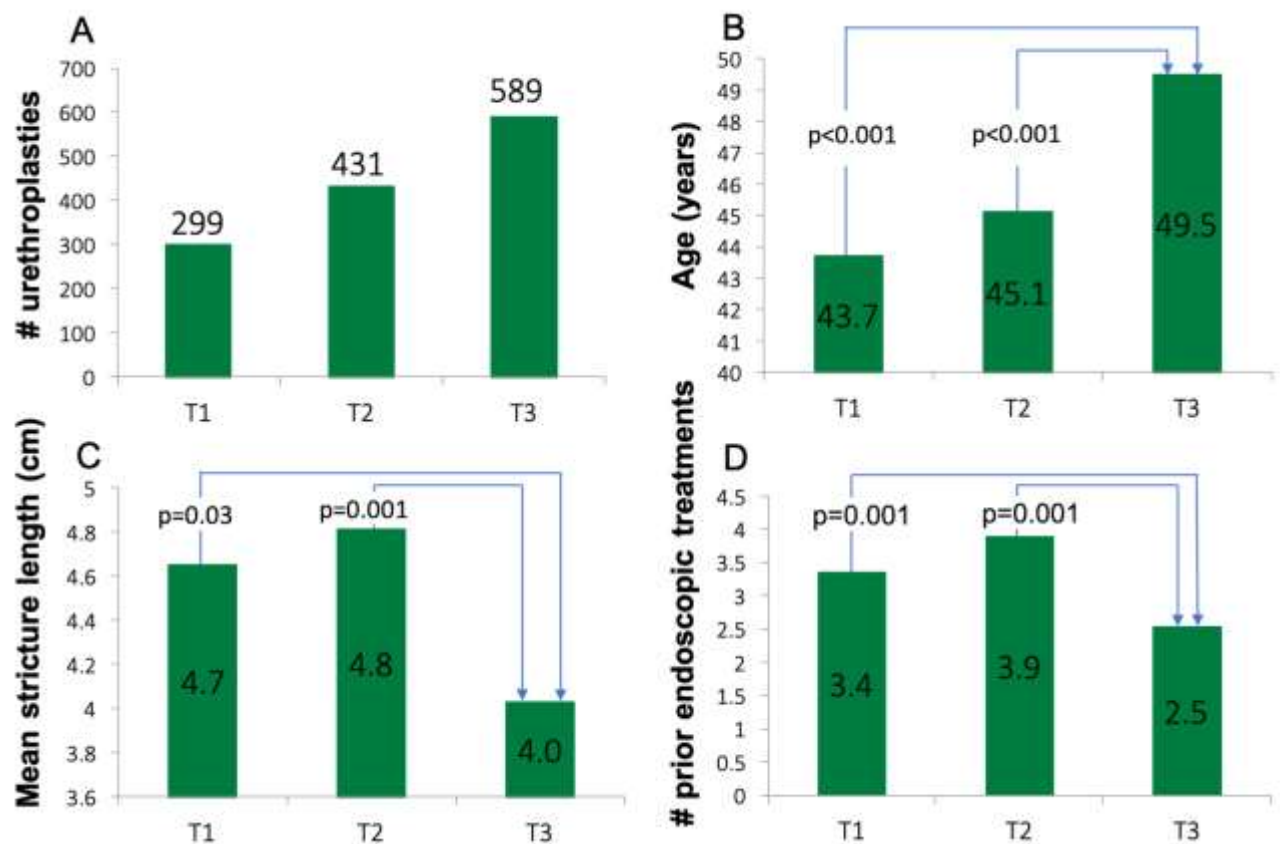
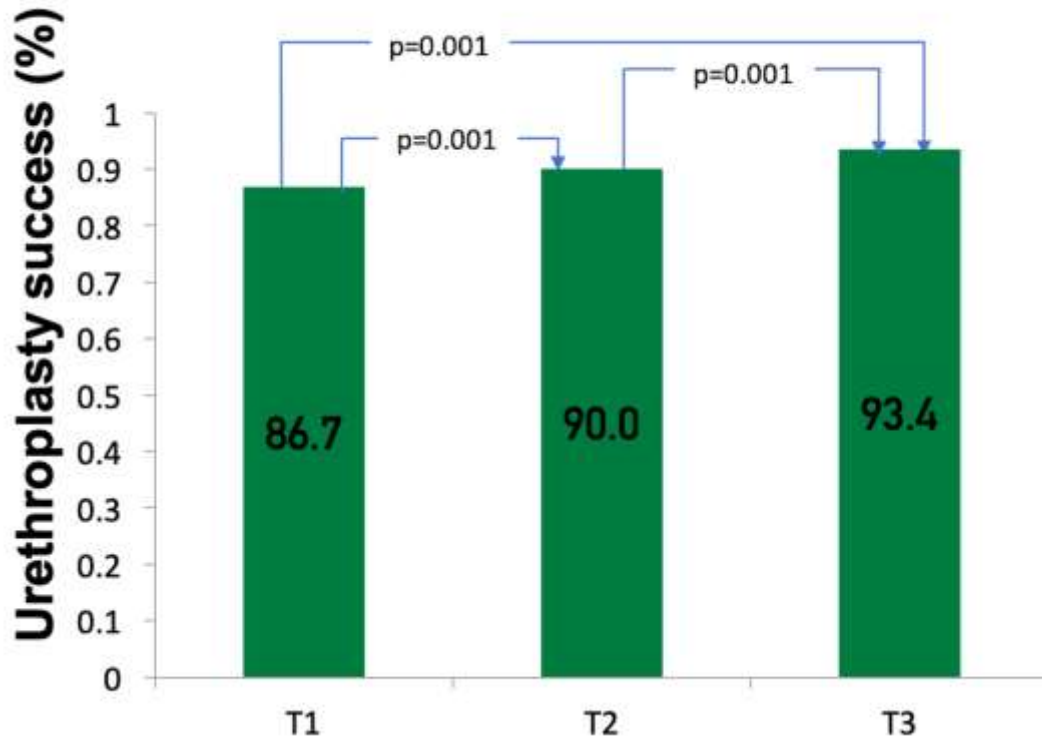


Figure 2. Cystoscopic success rate (%) stratified by tertile demonstrating a significant improvement over the 15-year study period and between tertiles.



Etiology	T1	T2	T3	p	OR	95% CI
Idiopathic	113 (39.8%)	169 (39.2%)	234 (39.7%)	0.59	1.04	0.90–1.20
Trauma	92 (30.8%)	88 (20.4%)	82 (13.9%)	<0.001*	0.60	0.51–0.72
Lichen sclerosus	23 (7.7%)	50 (11.6%)	74 (12.6%)	0.04*	1.27	1.01–1.59
Radiation	9 (3.0%)	22 (5.1%)	51 (8.7%)	0.001*	1.75	1.27–2.42
Hypospadias	34 (11.4%)	41 (9.5%)	64 (10.9%)	0.95	0.99	0.80–1.24
Iatrogenic	21 (7.0%)	47 (10.9%)	73 (12.4%)	0.02*	1.32	1.05–1.67
Inflammation/ infection	7 (2.3%)	14 (3.3%)	8 (1.4%)	0.21	0.75	0.47–1.17

*p<0.05. CI: confidence interval; OR: odds ratio.

Urethroplasty technique	T1	T2	T3	p	OR	95% CI
Anastomotic	96 (32.1%)	106 (24.6%)	171 (29.0%)	0.59	0.96	0.82–1.12
Buccal mucosa graft onlay	130 (34.4%)	214 (49.7%)	312 (53.0%)	0.009*	1.20	1.05–1.38
Fasciocutaneous flap onlay	18 (6.0%)	36 (8.3%)	16 (2.7%)	0.008*	0.67	0.50–0.90
Staged/ urethrostomy	50 (16.7%)	63 (14.6%)	60 (10.2%)	0.004*	0.75	0.61–0.91
Other	5 (1.7%)	12 (2.8%)	20 (3.4%)	0.15	1.39	0.89–2.16

*p<0.05. CI: confidence interval; OR: odds ratio.