Economic evaluation of urethroplasty vs. repeated endoscopic dilation in short bulbar urethral stricture management

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ABSTRACT

INTRODUCTION: Management of short bulbar urethral strictures (<2 cm) typically involves either endoscopic dilation or excision and primary anastomosis urethroplasty. While dilation is inexpensive and minimally invasive, it carries high recurrence rates. Urethroplasty is more durable but requires higher upfront resources. We conducted a decision analysis to compare the 10-year costs of both strategies.

METHODS: A decision tree was constructed to model stricture recurrence and complications after either index procedure. Direct institutional costs were obtained from hospital financial data and the Quebec physician fee schedule, expressed in 2023 Canadian dollars. Ten-year cumulative costs were calculated with a 3% annual discount rate. One-way sensitivity analyses varied recurrence and complication rates across published ranges.

RESULTS: The average cost of urethroplasty was $7186.27 CAD compared with $441.20 CAD for dilation. Stricture recurrence was 15.5% after urethroplasty vs. 60%, 80%, and 95% after first, second, and third dilations, respectively. Over 10 years, cumulative costs were $21 714.04 CAD for urethroplasty and $25 037.45 CAD for dilation, with a break-even point at approximately 80 months. Across sensitivity analyses, urethroplasty became more expensive with varying complication rates, but remained cost-efficient across a range of recurrence rates.

CONCLUSIONS: Despite higher initial expenses, urethroplasty is the more cost-efficient strategy for managing short bulbar urethral strictures. Given patients' relatively young age at diagnosis, cost benefits are likely to accrue beyond 10 years, supporting urethroplasty as the preferred definitive approach after at most one dilation attempt.

INTRODUCTION

Urethral stricture (US) is defined as the narrowing of the anterior portion of urethral lumen secondary to corpus spongiosum fibrosis.[1] It is a prevalent source of morbidity in urology, particularly among men, and is reported to affect 0.9% of industrialized nations.[2] Etiologies include inflammatory, iatrogenic (e.g., catheterization, instrumentation), traumatic, ischemic, and congenital causes.[3] Strictures in the bulbar portion of the anterior urethra are the most common,[4,5] and can lead to lower urinary tract symptoms (e.g., weak urinary stream, urinary hesitancy, straining to void).[6]

Short strictures that are <2 cm in length can be managed endoscopically (urethral dilation or direct visual internal urethrotomy) or surgically by urethroplasty.[1,6] Urethral dilation, the most frequently used endoscopic treatment, is performed in-office with minimal anesthesia. It is, however, associated with a stricture recurrence rate of 50–70%, which rises to 90–100% after two dilations and reaches nearly 100% after three.[7]

Urethroplasty is an open reconstructive surgery that requires greater resources, such as surgical expertise and brief hospital stay, but has a significantly more favorable recurrence rate for initial (15.5%) and subsequent strictures (15.9%).[5,6,8-10] Both the Canadian Urological Association (CUA) and the American Urological Association (AUA) recommend urethroplasty over repeated endoscopic procedures due to lower recurrence rates and cumulative long-term complications risk.[1,6] Nevertheless, its higher upfront costs due to opera-

KEY MESSAGES

- Urethroplasty has higher upfront costs but becomes less costly than repeated dilations within five years.
- Sensitivity analyses confirmed the robustness of urethroplasty's cost advantage.
- High recurrence rates make repeated dilations economically and clinically inferior over the long term.
- Definitive repair with urethroplasty better aligns with patient life expectancy and guideline recommendations.

tion room time, surgical supplies, and hospital bed-days to name a few, raise questions about cost efficiency.

Early modelling studies by Greenwell et al[8] and Rourke & Jordan[11] concluded that repeated endoscopic management is neither clinically effective, nor cost-efficient in the long term. They posited that after one endoscopic failure, proceeding to definitive urethral reconstruction minimizes overall costs and maximizes success. This topic, however, was not studied for urethral dilations, which unlike urethrotomy, can be in done in-office and have minimal upfront costs. The threshold at which urethroplasty becomes more cost-effective appears to depend on the success probability of endoscopic treatment and other clinical factors.[12]

We developed a decision analysis model comparing the long-term costs of treating short bulbar urethral strictures (<2 cm) with either excision and primary anastomosis (EPA) urethroplasty or urethral dilation. By incorporating both direct procedural and downstream complication costs over a 10-year period, we aimed to provide a robust cost comparison grounded in real-world clinical and financial data. Our study seeks to inform treatment decision-making by highlighting the economic implications of early definitive surgical management vs. repeated endoscopic intervention.

METHODS

This project was approved by our institution's research review board.

Decision tree development

We constructed a decision analysis model to estimate 10-year institutional costs for the management of short bulbar urethral strictures with either EPA urethroplasty or urethral dilations with S-dilators. The structure of the tree reflected two frequent and clinically relevant complications proceeding either index procedure (i.e., bleeding and urinary tract infections [UTI]), which were obtained via a retrospective review of urethral stricture cases treated by the senior author between 2018 and 2023. Bleeding was defined as macroscopic hematuria requiring emergency department (ED) assessment and one-day observation, and UTI was defined as bacterial cystitis diagnosed in the emergency department, with both complications assessed within a 30-day postoperative period.

An index case of a patient undergoing diagnosis and treatment for bacterial cystitis was used to estimate its treatment costs at our institution. Similarly, an index case of a patient experiencing postoperative hematuria was included for the basis of estimating the cost of managing bleeding.

A literature review was conducted to quantify the probabilities of clinically relevant events in order to enhance the generalizability of our findings.[1,13-21] Recurrence of strictures after either index procedure was modeled to trigger management with dilation. The final decision tree is depicted in Figure 1, and base case parameter values for recurrence probabilities, complication rates, event timing, and unit costs are summarized in Table 1. Postprocedure UTI and bleeding were modeled for both strategies as separate chance nodes.

Cost calculations

Costs were estimated from a governmental expenditure point of view. We included direct costs of the index procedures, postoperative complications, physician fees, and downstream costs of treatment for recurrences. Index procedure costs captured costs of the operation, personnel, equipment, and supplies, as well as costs from postoperative care leading up to patient discharge. Complication costs incorporated ED presentation, followup clinic visits, and inpatient care when applicable. Institutional cost data were sourced from hospital finance data and the provincial physician fee schedule (i.e., Régie de l'Assurance Maladie du Québec) and reported in 2023 Canadian dollars (CAD). A 3% annual discount rate was applied to future costs. We assumed complications and stricture recurrences were independent events conditional on the branch. As well, mortality and qualityoflife outcomes were not modeled, as our analysis focused only on direct costs to the institution.

Data analysis

All analyses were conducted in R (version 4.4.2, R Foundation for Statistical Computing, Vienna, Austria) with currency expressed in CAD.

The decision tree was traversed for each strategy and computed the expected costs as the probability-weighted sum of all terminal pathways' costs over 10 years, discounted at 3% annually. Next, the month-by-month cumulative cost trajectories were generated to reflect the difference in the recurrence interval for each procedure (i.e., 12 months for urethroplasty vs. three months for dilation). The cumulative cost trajectories were then used to calculate the break-even point. This figure was defined as the earliest month at which the cumulative expected cost curves for urethroplasty and repeated dilations intersected and reflects equal cumulative institutional spending.

To assess robustness of our data, we performed one-way sensitivity analyses varying one urethroplasty parameter at a time while holding others at their base-case values. The parameter ranges were informed by the published literature[1,6,14,16,17,19-23] and included 0-50% for stricture recurrence rate, 2–5% for bleeding, and 5–13% for UTI (Table 1). For each tested value, the 10-year cumulative costs were calculated for both treatment modalities and plotted in trajectories.

RESULTS

Base-case analysis

The baseline model parameters and values are illustrated in Table 2. The average total cost of urethroplasty (i.e., institutional and professional fees) at our centre was $7186.27 CAD compared to $441.20 CAD for urethral dilation. The rate of stricture recurrence was 15.5% for urethroplasty. Recurrence after urethral dilation varied by iteration: 60%, 80%, and 95% for the first, second, and third procedures, respectively. Strictures had a mean time-to-recurrence of 12 months for urethroplasty and three months for urethral dilation. The incidences of UTI and hematuria were 7% and 2%, respectively, for urethroplasty and were 4% and 2%, respectively, for urethral dilation. The overall costs of treating these complications were $1136.64 CAD for UTI and $3060.70 CAD for bleeding, as determined by our analysis of index patients who underwent either urethroplasty or urethral dilation by the senior author from 2018–2023 (Table 3).

The month-by-month cost trajectories of each procedure are shown in Figure 2. Urethroplasty is initially more expensive due to higher index procedure costs, but the cost curves converged over time as recurrent

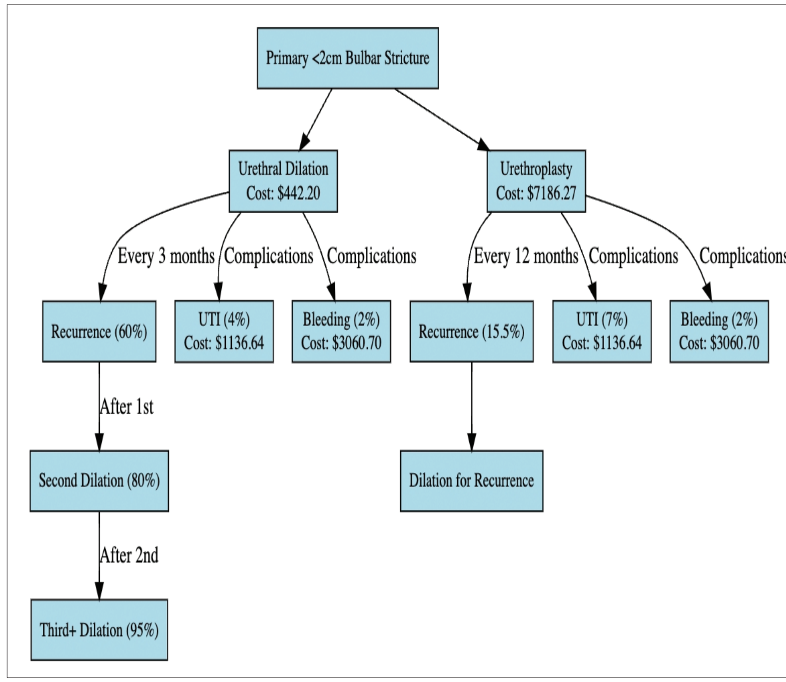

Figure 1. Flowchart demonstrating the two treatment pathways for a short primary bulbar urethral stricture.

Table 1. Base case parameter ranges for sensitivity analyses

Base case urethroplasty parameter	Range (%)
Stricture recurrence	5–20
UTI	5–13
Bleeding	2–5

UTI: urinary tract infection.

Table 2. Base-case parameters for urethroplasty and urethral dilation

Treatment strategy	Institutional fees (CAD)	Professional fees (CAD)	Stricture recurrence rate (%)	Stricture recurrence interval (months)	UTI incidence (%)	Bleeding incidence (%)
Urethroplasty	$5919.67	$1266.60	15.5	12	7	2
Urethral dilation	$341.20	$100.00	First: 60 Second: 80 Third: 95	3	4	2

UTI: urinary tract infection.

Table 3. The institutional costs of two clinically relevant complications

Post-procedure complication event	Cost (CAD)
UTI	$1136.64
Bleeding	$3060.70

UTI: urinary tract infection.

Table 4. Costs and points of interception

	Value
Cumulative cost of urethroplasty in 10 years (CAD)	$21 714.04
Cumulative cost of urethral dilation in 10 years (CAD)	$25 037.45
Point of intersection (month)	80
Urethroplasty UTI rate at the intersection point (%)	10
Urethroplasty bleeding rate at the intersection point (%)	3%

UTI: urinary tract infection.

events accumulated in the dilation arm. The break-even point was identified at approximately 80 months — i.e., the institutional cost of urethroplasty and subsequent treatments for strictures and complications reached that of urethral dilation in seven years. Over 10 years, cumulative costs were $21 714.04 CAD for urethroplasty and $25 037.45 CAD for urethral dilation (Table 4).

Sensitivity analysis

To identify whether there is a threshold at which urethral dilation would become more cost-efficient than

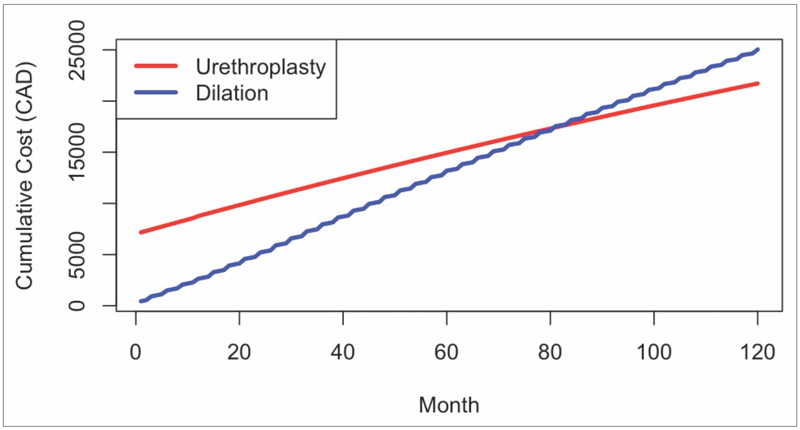

Figure 2. Cumulative cost comparison of undergoing urethroplasty vs. urethral dilations projected over a 10-year interval.

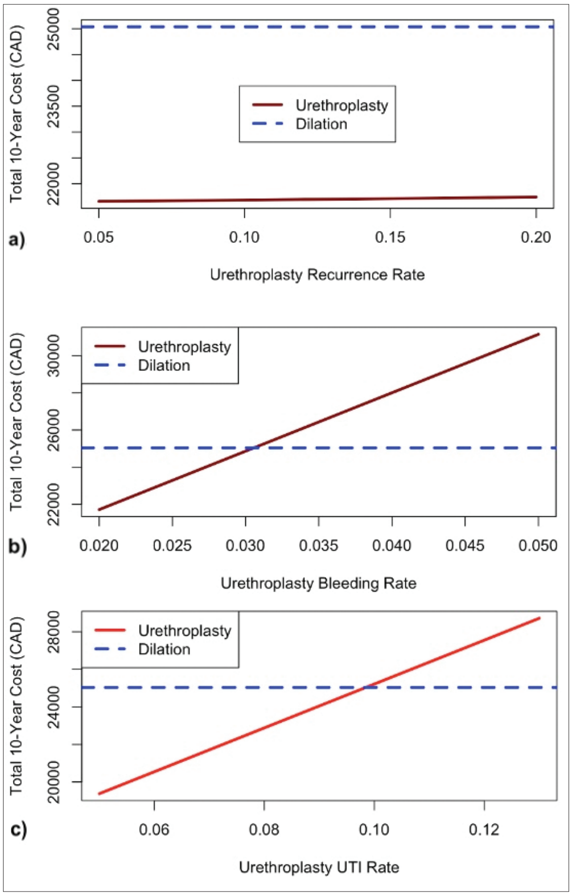

Figure 3. 10-year cumulative costs of urethroplasty and repeated dilations across one-way sensitivity analyses varying (A) urethroplasty recurrence, (B) bleeding, and (C) urinary tract infection rates.

urethroplasty, we performed sensitivity analyses by adjusting the parameters' probabilities (i.e., incidence of recurrence, bleeding, and UTI) across a range of plausible values (Table 1).[11] Varying the urethroplasty stricture recurrence rate from 5–20% did not alter the overall finding that urethroplasty was less costly than urethral dilation at ten years (Figure 3). When the urethroplasty bleeding rate was varied from 2–5%, the cumulative cost of urethroplasty surpassed that of dilation above 3% (Figure 3, Table 4). Similarly, increasing the UTI rate from 5–13% led to an eventual reversal of the cost advantage of urethroplasty. That is, while recurrence rate variation had little influence on the cost comparison, higher complication rates can shift the balance towards dilation.

DISCUSSION

Short bulbar US present a unique urologic problem as its management can be done endoscopically by dilation or urethrotomy, as well as surgically via urethroplasty. Despite being a less expensive treatment strategy, urethral dilations are associated with high recurrence rates,[7] and the current guidelines favor urethroplasty for recurrent stricture formers;[1,6] however, there remain questions about the cost efficiency of urethroplasty given its higher associated costs. We demonstrate in our study, through a decision analysis model, that despite its higher upfront expenses, urethroplasty is a cost-minimizing strategy for the treatment of short bulbar US.

Economic and clinical implications

Our base case model showed that while urethroplasty has higher initial costs (due to operating room time, hospital stay, etc.), the cumulative 10-year cost of the two strategies converged at about 84 months. That is, repeated endoscopic dilations will ultimately result in higher costs over the long-run at 10 years. This finding is consistent with the study by Rourke and Jordan, who showed that immediate anastomotic urethroplasty was less costly over time than endoscopic management, resulting in a cost reduction of $1300 per patient.[11]

Similarly, another study demonstrated that treating US with one endoscopic attempt followed by open reconstructive urethroplasty for recurrences was the most cost-efficient approach as opposed to repeated endoscopic treatments.[8]

Our results reinforce that continued dilations become economically costly long term, likely due to high recurrence rates resulting in multiple repeat interventions. In practice, our model supports the paradigm that while a single endoscopic dilation may be a reasonable option at first, repeated dilations for recurrent strictures is economically inferior to a one-time curative urethroplasty. The finding that the durability of an initial endoscopic dilation is quite modest supports that paradigm and favors urethroplasty as an early treatment strategy.

Interestingly, the recent study called the Open Urethroplasty vs. Endoscopic Urethrotomy (OPEN) trial, illustrated that the reported quality of benefits was comparable between urethroplasty and endoscopic management, while the index costs of the former was higher.[24] The authors concluded that given those findings, repeated endoscopic management is more cost-efficient. That study, however, was limited to a followup interval of two years, and it assessed cost per quality-adjusted life year (QALY) rather than pure cost-minimization. The lack of an observed QALY gain from urethroplasty over two years may be explained by the fact that urethroplasty carries a higher immediate recovery burden given its more invasive nature.

Over a longer term, as is the case in our study, one would expect that the differences in stricture recurrence rates lead to both cost savings and QALY gains for those undergoing urethroplasty as their index procedure. While not necessarily contradictory, the result of the OPEN trial highlights the importance of time horizon. In practical terms, policymakers and surgeons should recognize that initial endoscopic management may appear cheaper for the first year or two, but if the stricture is likely to recur, the tipping point arrives by about seven years, where the accumulated costs of repeated dilations overtake a one-time surgical treatment.

Of note, US is typically diagnosed, on average, in the age range of 38-64 years.[23,25,26] Since those patients are expected to live well beyond the seven-year time frame, the cost benefits of definitive repair with urethroplasty is likely to accrue, further supporting its employment as an initial treatment strategy. Nevertheless, in patients with limited life expectancy and/or multiple comorbidities, conservative management with periodic dilations might be more cost-efficient.

Furthermore, from a clinical standpoint, urethroplasty can spare patients the morbidities associated with chronic stricture management, such as UTIs, difficult catheterizations, urosepsis and renal failure.[23,27] Therefore, definitive US management can reduce such downstream health issues, and may lead to an important quality-of-life benefit that is not captured via a cost analysis.

In summary, our analysis demonstrates that while urethroplasty carries higher upfront costs, its durability and lower recurrence rates make it the more cost-efficient strategy for most patients over the long term. The economic advantages, combined with potential reductions in morbidity and alignment with established clinical guidelines,[1,6] support its consideration as the preferred treatment approach for urethral strictures in patients with sufficient life expectancy and surgical candidacy.

Sensitivity analysis

Consistent with the base case model, the economic advantage of urethroplasty persisted across a wide range of recurrence probabilities. Through testing ranges of parameters assuming best- and worst-case scenarios, we show that varying the urethroplasty recurrence rate between 5% and 20% did not alter the overall 10-year cost comparison. In contrast, increasing the bleeding and UTI rates led to a reversal of the 10-year cost difference. These findings indicate that the model is relatively resistant to changes in recurrence rates but is sensitive to changes in postoperative complication rates.

Together, these results suggest that the economic comparison depends primarily on complication rates, while variations in recurrence alone have no influence on the overall 10-year cost. In our base-case model, urethroplasty is the more cost-efficient option since the complication estimates are lower than the values explored in the sensitivity analyses.

Strengths and limitations

Our study offers a detailed contemporary cost analysis from an institutional perspective that is relevant to healthcare decision-making, especially in a Canadian context. We captured a meaningful timeframe during which difference in recurrence rates between endoscopic and surgical managements translate into tangible cost differences. Our findings support the paradigm of moving beyond considering immediate perioperative costs that favor dilations in the short-term.

We enhanced the generalizability of our findings by incorporating real-world procedural cost data with commonly reported probability of clinically relevant complications of each procedure from the literature. Our study also benefits from alignment with several prior research that have informed clinical guidelines.[1,6,11] This convergence of evidence further strengthens the validity of our conclusions and suggest that despite differences in absolute dollar amounts, the overall economic advantage of urethroplasty remains consistent.

We also acknowledge several limitations of our study. First, our model examined two common yet extreme strategies — immediate urethroplasty vs. repetitive dilations. Such an approach might simplify the treatment algorithm that patients follow. In practice, the guidelines recommend an initial dilation followed by urethroplasty upon recurrence for patients presenting with a first episode of US.[1,6] Not modeling such a real-world approach is a limitation; however, it would not be unreasonable to infer that the cost of that hybrid strategy would lie between our two extremes and closer to the urethroplasty-only approach. Indeed, Greenwell et al demonstrated that one endoscopic attempt followed by surgical management was more cost-efficient than repeated endoscopic attempts.[8]

Second, we did not include drug-coated balloon dilators, such as taxane-coated devices. Despite improved recurrence outcomes compared with previous dilation techniques,[28] they are not routinely used in Quebec, and their cost structures are not established in a way that permits reliable modeling. Future cost analyses should incorporate these new dilators as their adoption increases to provide a more complete comparison.

Third, the cost estimates were drawn from a single tertiary center in Quebec. Urethral dilations are performed across multiple settings in Canada (e.g., outpatient clinics, ambulatory units, physician offices, etc.), and each environment has different resource requirements and relevant expenses. Practice patterns vary with respect to the type of dilators used, which also influence costs. Because detailed data related to these factors were not consistently available, we were unable to model this variability. Thus, the generalizability of our cost estimates to other Canadian centers is limited.

Fourth, our study takes on an institutional healthcare paper perspective, and does not factor in the indirect costs incurred to the patient, nor the economy at large. For instance, the recovery from urethroplasty is longer than endoscopic dilation, which could hinder patients' ability to work and contribute to the economy more than if they were to undergo dilations. On the other hand, repeated dilations might be cumbersome to patients, as repeated visits require multiple absences from work.

Fifth, our reductionist model examines only two forms of complications, although other postoperative complications exist. They were deemed, however, less economically impactful given their low incidence.

Lastly, the findings of our study rely on single institutional cost data. While we attempted to enhance the generalizability of our findings by incorporating key complication probabilities from the literature, our study does not reflect every practice setting.

CONCLUSIONS

In our decision analysis model, EPA urethroplasty was consistently less costly over a 10-year period than repeated urethral dilations for the treatment of short bulbar US, despite higher upfront procedural expenses. This cost advantage persisted across variations in recurrence probabilities, while raising complication rates above the average estimates led to a loss of this advantage. Given the high recurrence rates associated with repeated dilations and the relatively young age at diagnosis for many patients, the economic benefit of definitive surgical repair is likely to increase over a patient's lifetime. These results support existing guideline recommendations favoring urethroplasty for recurrent strictures and suggest that, beyond an initial endoscopic attempt, further resources are best directed toward durable surgical reconstruction.

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This paper has been peer-reviewed.

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