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RESEARCH

Factors associated with restenosis and postoperative complications in patients undergoing buccal mucosal graft urethroplasty: retrospective analysis

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Abstract

Background: Urethral stenosis is a challenging urological condition, and its management includes a variety of techniques broadly classified as endoscopic approaches or reconstructive procedures using graft urethroplasty. Buccal mucosal graft urethroplasty is currently considered the gold standard for the treatment of anterior urethral stenosis. However, the literature remains inconclusive regarding the influence of patient-related factors on therapeutic success or failure, particularly with respect to restenosis. This study aimed to evaluate risk factors for urethral restenosis and postoperative complications following buccal mucosal graft urethroplasty.
Methods: A retrospective review of medical records was conducted for patients with anterior urethral stenosis who underwent buccal mucosal graft urethroplasty between September 2012 and December 2019 at a public hospital in Curitiba, Paraná, Brazil.
Results: A total of 51 patients were included in the analysis. No statistically significant patient-related risk factors for urethral restenosis were identified. However, a history of prior endoscopic prostate resection was associated with an increased risk of postoperative complications following urethroplasty, and this association was correlated with patient age.
Conclusion: These findings contribute to identifying factors associated with postoperative complications, facilitating improved preoperative risk stratification and patient counseling. Recognizing patients at higher risk may enable clinicians to anticipate postoperative outcomes and tailor perioperative management after buccal mucosal graft urethroplasty.
Keywords: Urethra, urethral stenosis, reconstructive surgery, buccal mucosal graft urethroplasty

Introduction

Male urethral stenosis is characterized by a narrowing of the urethral lumen, most commonly resulting from fibrosis or inflammatory processes [1]. This condition may arise from multiple etiologies, including pelvic trauma, sexually transmitted infections, other infectious and inflammatory conditions, iatrogenic causes, hypospadias, prostate cancer, radiotherapy, urethral calculi, prolonged urinary catheterization, and idiopathic factors [2-5]. Additionally, urethral stenosis can develop as a postoperative complication following surgical procedures, including transurethral resection of the prostate (TURP), transvesical adenectomy, and radical prostatectomy [5]. Stenosis may affect any segment of the urethra, including the prostatic, membranous, bulbar, and penile urethra, as well as the navicular fossa or bladder neck. It may present as annular, short, or long segments with varying degrees of associated inflammation [1].

Therapeutic strategies for urethral stenosis aim to reestablish adequate urinary flow and enhance quality of life. Multiple surgical approaches are available, with treatment selection guided by the size and complexity of the stenotic

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lesion. Internal urethrotomy is typically more effective in cases of small or annular stenosis [1, 3, 6]. In contrast, urethrectomy is preferred for stenosis shorter than 2 cm associated with substantial fibrosis. In more complex cases, graft urethroplasty is often indicated [3]. Buccal mucosa is the preferred graft material, chosen over other tissues such as skin, bladder epithelium, tunica vaginalis, or intestinal mucosa because of its favorable characteristics, including excellent vascularity, ease of harvest, high elastin content, and the absence of hair or other appendages [3, 7].

Reported long-term success rates for buccal mucosal graft urethroplasty range from 73% to 93.3% [8-10]. Factors influencing restenosis include obesity, smoking, alcohol consumption, chronic comorbidities, age, previous urethral surgeries such as TURP, as well as the location, size, and etiology of the stenosis [5, 10, 11]. In a meta-analysis, Yoshikawa *et al*. [12] identified penobulbar location, stenosis length (> 7 cm), and diabetes mellitus as the main risk factors for restenosis after a buccal mucosal graft urethroplasty. Surgical decision-making should rely on the best available evidence, established clinical guidelines, and the surgeon's expertise, while incorporating patient-specific characteristics into an individualized approach. However, there is no consensus regarding which risk factors contribute to poor outcomes in stenosis correction procedures. Therefore, when patient data are available, it is possible to explore whether patient-related factors identified during clinical assessment are associated with restenosis and postoperative complications.

In this context, more robust scientific evidence is essential to guide medical decision-making and optimize success rates in buccal mucosal graft urethroplasty. Therefore, this study aimed to identify risk factors for restenosis and postoperative complications after buccal mucosal graft urethroplasty, based on a small, single-center retrospective analysis at a public hospital in Brazil.

Methods

A retrospective study was conducted extracting the target data from the medical records of patients who underwent urethroplasty with a buccal mucosal graft for the treatment of urethral stenosis (> 2 cm). Data from patients who needed the use of combined surgical techniques (*i.e.*, buccal mucosal graft urethroplasty combined with segmental urethrectomy, or the use of multiple graft types) were not included. All procedures were performed at the Urology Department of a public health service hospital in Curitiba, Paraná, Brazil, between September 2012 and December 2019. The study was approved by the Research Ethics Committee of the public health hospital in Curitiba, Brazil (CAAE: 58826416.6.0000.0020; protocol no. 082136/2016).

The following variables were evaluated as potential predictors of outcome: stenosis size, anatomical location (penile or bulbar), etiology, age, tobacco use, history of prior procedures, and prior cystostomy. Postoperative complications were recorded, along with the interventions required for their management. Surgical success was defined as urethroplasty without the need for additional dilations and with satisfactory voiding patterns during a one-year follow-up period. Continuous data are presented as mean ± standard deviation (SD) for parametric variables and as median with interquartile range for nonparametric variables. Normality was assessed using the Shapiro–Wilk test. Categorical data are expressed as frequencies and percentages. Comparisons between stenosis size and age were performed using Student's t test or the Mann–Whit-

Table 1. Characteristics of the study population.

Patients' characteristics	All	No restenosis	Restenosis
Number of participants (%)	51	38 (74.5%)	13 (25.5%)
Age (years)	55.43 ± 14.88	56.16 ± 14.65	53.31 ± 15.96
Stenosis size (cm)	6.775 ± 4.399	6.303 ± 4.078	8.154 ± 5.157
Smoker (%)	6 (11.8)	5 (13.2)	1 (7.7)
Stenosis cause			
Trauma (%)	10 (19.6)	7 (18.4)	3 (23.1)
Infection (%)	17 (33.3)	12 (31.6)	5 (38.5)
Urinary catheter (%)	9 (17.6)	7 (18.4)	2 (15.4)
TURP (%)	7 (13.7)	4 (10.5)	3 (23.1)
Idiopathic (%)	9 (17.6)	8 (21.1)	1 (7.7)
Cystostomy	17 (33.3)	12 (31.6)	5 (38.5)
Previous procedure			
Dilatation (%)	7 (13.7)	5 (13.2)	2 (15.4)
Urethrotomy (%)	11 (21.6)	6 (15.8)	5 (38.5)

Note: TURP: transurethral resection of the prostate.

Table 2. Odds ratio estimation for factors associated with restenosis.

Factor	OR	CI 95%		*P*-value	Pearson's χ^2	Cramér's V
Smoker	0.550	0.058	5.199	0.598	0.279	0.073
Former smoker	0.708	0.072	6.981	0.767	0.088	0.042
Trauma	1.329	0.288	6.128	0.715	0.133	0.051
Infection	1.354	0.365	5.019	0.650	0.206	0.064
Urinary catheter	0.805	0.145	4.476	0.804	0.061	0.035
TURP	2.550	0.487	13.340	0.256	1.288	0.159
Idiopathic	0.313	0.035	2.776	0.275	1.190	0.153
Cystostomy	1.302	0.351	4.837	0.693	0.156	0.056
Previous urethral surgery	2.174	0.513	9.221	0.286	1.140	0.150
Stenosis size (small: < 4 cm)	0.494	0.129	1.884	0.297	1.088	0.146
Stenosis size (medium: 4-8 cm)	2.014	0.525	7.726	0.303	1.062	0.144
Stenosis size (large: > 8 cm)	1.091	0.277	4.296	0.901	0.015	0.017

Note: TURP: transurethral resection of the prostate.

Table 3. Odds ratio estimation for factors associated with postoperative complications (*i.e.*, urethral infection, urinary tract infection, purulent drainage, penoscrotal abscess, and hematoma).

Factor	OR	CI 95%		*P*-value	Pearson's χ^2	Cramér's V
Smoker	1.300	0.129	13.132	0.824	0.050	0.031
Infection	0.773	0.134	4.469	0.774	0.083	0.040
TURP	7.500	1.220	46.096	0.016*	5.815	0.338
Idiopathic	0.750	0.079	7.125	0.802	0.63	0.035
Cystostomy	0.350	0.038	3.265	0.339	0.913	0.135
Previous urethral surgery	3.778	0.418	34.172	0.210	1.568	0.175
Stenosis size (small: < 4cm)	0.987	0.197	4.944	0.987	0.000	0.002
Stenosis size (medium: 4-8 cm)	2.250	0.434	11.659	0.325	0.967	0.138
Stenosis size (large: > 8 cm)	0.357	0.039	3.256	0.344	0.894	0.132

Note: *indicates statistical significance.

ney U test, as appropriate. Associations between outcomes and dichotomous categorical variables were evaluated using 2 × 2 contingency tables, with odds ratios (ORs) and 95% confidence intervals (CIs) calculated by cross-tabulation. The chi-square (χ^2) test was applied to identify statistically significant associations, with results expressed as Pearson's χ^2 coefficient. Effect size was assessed using Cramér's V coefficient, with values ≤ 0.2 indicating weak, 0.2–0.6 moderate, and > 0.6 strong associations. A two-tailed *P*-value < 0.05 was considered statistically significant. All statistical analyses were performed using PASW Statistics (SPSS) version 18 and GraphPad Prism version 8.4.2.

Results

A total of 51 patients who underwent urethroplasty with a buccal mucosal graft were included in the retrospective analysis (Table 1). Among these, 13 patients (25.5%) developed restenosis within one year after the procedure. An initial analysis was performed to evaluate the association between restenosis and potential risk factors (Table 2). No statistically significant associations were identified for smoking status or for stenosis etiology, including trauma, infection, prior urinary catheterization, previous transurethral surgery, or idiopathic causes. The use of cystostomy for urinary obstruction was not statistically associated with an increased risk of restenosis. Likewise, no higher incidence of restenosis was observed among patients with a history of prior urethral surgery. In both scenarios, including analyses stratified by stenosis size, no significant risk factors for restenosis were identified.

In the second stage of evaluation, we calculated the same parameters while analyzing the risk of postoperative complications (Table 3). In this stage, we found that patients who had undergone previous TURP had an increased risk of postoperative complications. A total of seven cases of

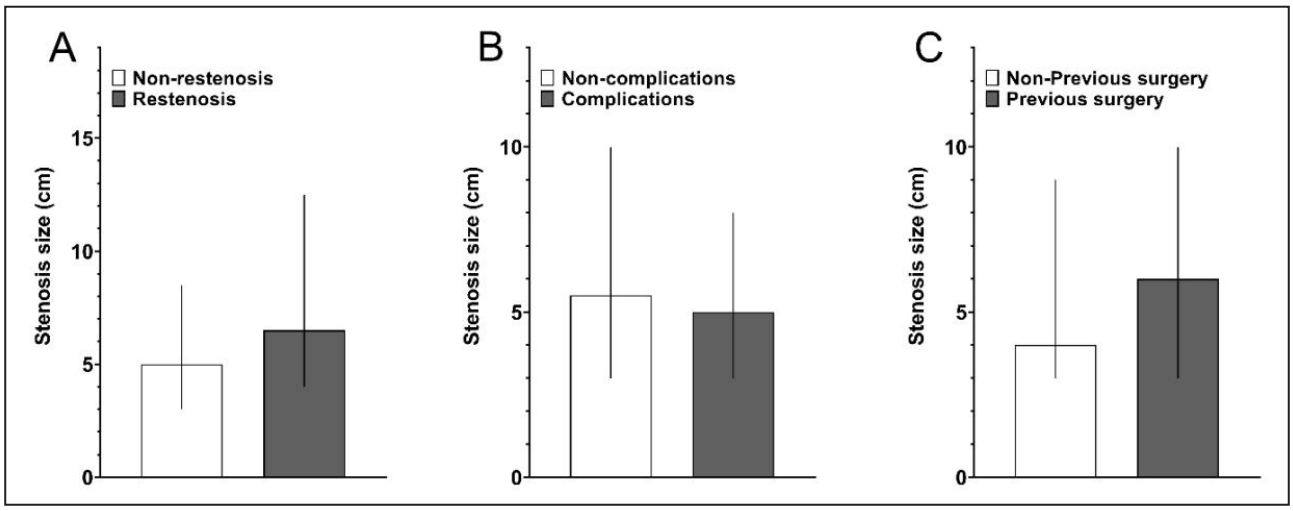

Figure 1. **Stenosis size in patients with restenosis (A) and complications (B) compared to patients without these outcomes, and stenosis size in patients who underwent prior surgery compared to those without previous surgery (C).**

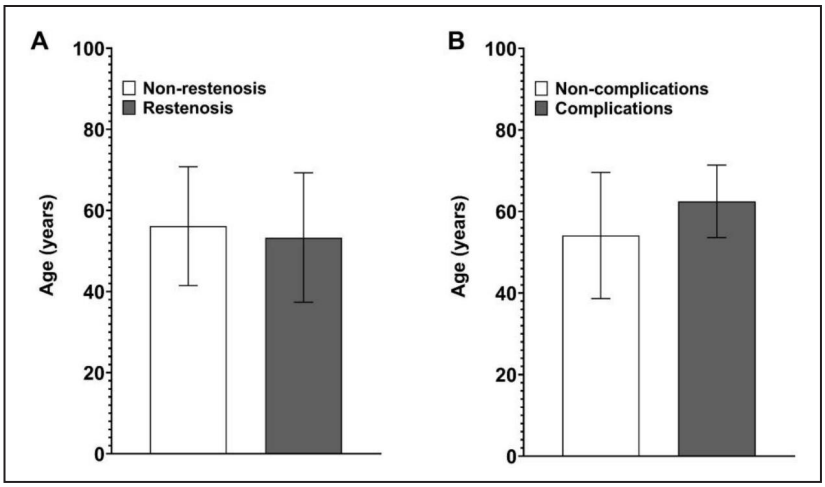

Figure 2. **Age range comparison between patients with restenosis (A) and complications (B) versus patients without these outcomes.**

complications were observed in the TURP group, including one case of infection with penoscrotal abscess, two cases of hematomas, one case of urethral infection, and two cases of urinary tract infections.

In the third stage, stenosis size was compared between patients with and without restenosis. Additionally, stenosis size was evaluated according to the occurrence of other complications and prior surgical history (Figure 1). No statistically significant differences were observed among the evaluated parameters. In the final stage, patient age was compared between those who developed restenosis and those who did not (Figure 2), and no statistically significant difference was detected between the groups.

Furthermore, we evaluated whether patient age differed between those who underwent stenosis correction and developed the complication of TURP and those who did not. A statistically significant age difference was observed between the two groups (Figure 3; unpaired t-test, $P < 0.05$; $t = 3.62$, $df = 49$), suggesting that the occurrence of this complication may be associated with patient age at the time of stenosis correction.

Discussion

Although treatment strategies for urethral stenosis are well established, the factors contributing to restenosis are not completely understood. Considerable controversy persists regarding potential risk factors, including hypertension, diabetes mellitus, coronary artery disease, smoking, prior surgical interventions, as well as the length and anatomical location of the stenosis [10-14]. The heterogeneity of existing studies and the variability in patient populations impair the proper identification of consistent predictors of restenosis.

Obesity and smoking are frequently reported as factors potentially associated with increased failure rates following urethroplasty due to urethral stenosis [15, 16]. Smoking, particularly when combined with poor oral hygiene, may impair wound healing and negatively affect graft quality [16]. Additionally, diabetes mellitus and tobacco use are known to promote microvascular damage, which may compromise tissue repair and healing after urethroplasty [14, 16, 17]. However, in our study, no significant association was observed between smoking and urethral stricture recurrence. Similarly, in a cohort of 596 patients undergoing urethroplasty (40.3% buccal mucosal graft urethroplasty), Chapman *et al*. [10] reported that smoking

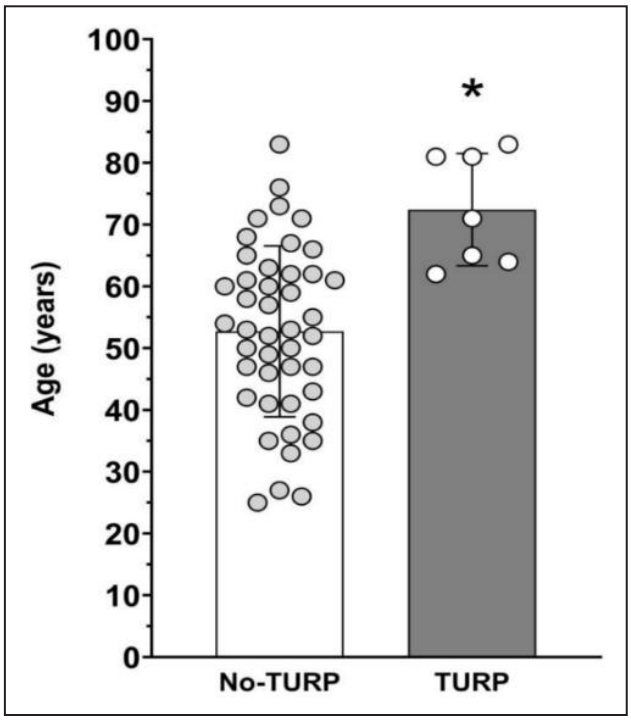

Figure 3. **Age range comparison between patients with transurethral prostate resection (TURP) and patients without this outcome (No-TURP)**. * indicates a statistically significant difference compared to the group without the outcome.

was not independently associated with stenosis recurrence on multivariate analysis. These findings are consistent with a previous meta-analysis conducted by our research group [12].

Our cohort comprised middle-aged to elderly patients, with a mean age of 55 years. Spilotros *et al*. [18] reported a significant association between age and surgical outcomes following various forms of buccal mucosal graft urethroplasty. Their findings demonstrated superior results in younger patients, with a recurrence rate of 6.3% in individuals under 30 years of age, compared with 15.2% in those aged 31–50 years and 35.1% in patients older than 50 years. While the literature report that urethral strictures are most commonly reported in elders [19], our analysis did not find the same association. These discrepancies may reflect differences in patient selection, the range of patient's age included in the study, comorbidity profiles, or methodological variations between studies, highlighting the ongoing uncertainty regarding the role of age as an independent predictor of urethroplasty success. Breyer *et al*. [11] also reported increased age as a risk factor for restenosis. Similarly, our retrospective analysis of urethral stenosis secondary to TURP demonstrated that older age was significantly associated with a higher incidence of complications. These findings suggest that impaired urethral vascularization, combined with age-related microvascular alterations, may contribute to poorer outcomes in older patients.

One of the major controversies in the literature is whether stenosis etiology influences the risk of urethral restenosis. Inflammatory etiology has often been suggested as an independent risk factor for recurrence [10, 14]. However, Spilotros *et al*. [18] did not confirm this association in their multivariate analysis. Similarly, in agreement with both Spilotros *et al*. [18] and the meta-analysis conducted by our research group [12], our study did not detected a statistically significant association between inflammatory etiology and higher recurrence rates. Taken together, these findings suggest that etiology alone may not be a reliable predictor of surgical success following urethroplasty.

Several studies suggest that prior urethral interventions, including urethroplasty and endoscopic procedures such as direct visual internal urethrotomy or dilation, may serve as independent predictors of urethral stricture recurrence [10, 11, 20]. In the present study, however, previous endoscopic treatment or dilation was not associated with increased restenosis rates. Although not routinely recommended as definitive conduct, this finding suggests that endoscopic interventions may be used as temporary measures without negatively impacting outcomes following subsequent urethroplasty. Conversely, the higher recurrence risk observed in patients with a history of prior urethral reconstruction may be related to extensive fibrosis and ischemic changes at the stricture site, which can compromise tissue quality and surgical success [5].

Previous urethroplasty has been identified as a predictive factor for recurrence in some studies [5]; however, in agreement with our previous meta-analysis [12], our findings did not demonstrate adverse effects of prior urethroplasty on restenosis after repeat intervention. These discrepancies across studies may reflect differences in patient selection, surgical techniques, or definitions of treatment success.

Stricture length has also been proposed as an important determinant of surgical outcomes. Success rates for buccal mucosal grafting appear to decrease in strictures longer than 7 cm, potentially due to compromised vascular supply and challenges in graft integration. We previously reported in a meta-analysis study [12] lower success rates in extensive strictures (> 7 cm), while shorter strictures were identified as a protective factor against recurrence. This meta-analysis demonstrated statistical significance for a mean stricture length of approximately 7 cm as a threshold associated with restenosis risk. In contrast, our analysis did not identify stricture length as a significant predictor, even when subdividing cases into groups at 4-cm intervals.

Notably, a history of prior endoscopic prostate resection was associated with an increased risk of postoperative complications following urethroplasty, and this association appeared to correlate with patient age. In our retrospective cohort, previous prostate resection was significantly associated with higher complication rates. We postulate that this relationship stems from the use of larger-caliber instrumentation in urethras with already compromised vascularity, particularly in cases of prostatic enlargement where procedural duration is often prolonged. We hypothesize that prolonged instrumentation induces transient ischemia through radial compression exceeding capillary perfusion pressure, thereby triggering microvascular injury and subsequent fibrotic remodeling. Consistent

with this hypothesis, El-Kassaby *et al*. [21] identified inflammation and ischemia as independent risk factors for restenosis. In elderly patients, whose vascular reserve is already diminished by age-related changes, such ischemic insults may accelerate spongiofibrosis through the replacement of elastic tissue with dense collagen. Thermal effects from resectoscopic energy may further exacerbate local tissue injury.

This study reflects the experience of a single surgeon in a teaching hospital setting with resident participation and a moderate volume of urethroplasty procedures. Several important limitations must be acknowledged. First, the retrospective design and relatively small sample size limit the statistical power of the analysis and increase the risk of type II error, restricting the ability to detect true associations. In addition, the single-center nature of the study and the involvement of a single surgeon may limit the generalizability of the findings. The absence of a standardized follow-up protocol may have introduced variability in outcome assessment. Furthermore, the study lacked detailed information on the control and severity of comorbid conditions, such as hypertension and diabetes mellitus, which may act as important confounders. Given these constraints, the findings, particularly any observed associations, should be interpreted with caution and should not be considered definitive evidence of causal relationships, but rather as exploratory signals that warrant confirmation in larger, adequately powered prospective studies.

Conclusions

This retrospective analysis demonstrates that anterior urethroplasty using a buccal mucosal graft remains an effective treatment for urethral strictures, yielding favorable outcomes and a low overall recurrence rate. However, a history of prior TURP emerged as a significant risk factor for postoperative complications. Critically, within this specific TURP subgroup, advanced age was further associated with a heightened complication rate, a correlation that was not observed in the broader study population. These findings suggest that elderly patients with a history of prostate resection represent a high-risk phenotype, particularly susceptible to infectious complications and hematomas. Consequently, this subset may require more rigorous perioperative antibiotic protocols and vigilant vascular monitoring to mitigate their unique risk profile. Prospective studies are warranted to further evaluate the role of potentially modifiable risk factors and to assess their impact on long-term outcomes following urethroplasty with buccal mucosal grafts.

Declarations

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Availability of data and materials: All the data are presented in the results section.

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