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The Surgical Learning Curve for One-stage Anterior Urethroplasty: A Prospective Single-surgeon Study

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Abstract

Background: The learning process for one-stage anterior urethroplasty has never been addressed before.
Objective: To evaluate the surgical learning curve for one-stage anterior urethroplasty.
Design, setting, and participants: Data from 641 consecutive patients treated with one-stage urethroplasty for urethral stricture were collected prospectively. All the procedures were performed by a single surgeon between 1994 and 2014.
Intervention: One-stage anterior urethroplasty using substitute tissues.
Outcome measurements and statistical analysis: The outcome was treatment failure, defined as any postoperative instrumentation needed including dilation. Surgeon experience was coded as the total number of one-stage urethroplasties performed by the surgeon before the operation. Multivariable Cox regression analysis was used to evaluate the association between surgeon experience and treatment failure. Covariates consisted of age, body mass index, smoking history (no, yes, ex-smoker), diabetes history (no or yes), previous surgical treatments (no or yes), stricture length, and stricture site (bulbar, penile, panurethral).
Results and limitations: Overall, 546 patients (85%) were treated with one-stage oral mucosa urethroplasty; penile skin or skin flap was used in 95 patients (15%). Median follow-up among patients who did not experience surgical failure was 69 mo (interquartile range: 35–118). The failure-free survival at 5 yr was 77% (95% confidence interval [CI], 74–81). At multivariable analysis, surgeon experience was significantly associated with a lower probability of treatment failure (hazard ratio per 20 procedures: 0.98; 95% CI, 0.97–0.99; $p = 0.008$). The surgical learning curve appeared lengthened, without reaching a plateau even after 600 procedures.
Conclusions: In this single-surgeon analysis, surgical experience has a significant impact on the probability of treatment success for one-stage urethroplasty. Better results are achieved only after a long learning curve that may not be justifiable for late-career and low-volume surgeons.
Patient summary: The probability of surgical success after one-stage urethroplasty is importantly influenced by surgeon experience. Better results are achieved only after a very long learning process.

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1. Introduction

The management of urethral strictures remains a challenging issue in the urologic practice [1]. Endoscopic procedures such as optical internal urethrotomy and urethral dilation continue to play an important role for initial treatment. However, reconstructive urethral surgery has gained effectiveness in recent years due to its superior long-term outcomes [2–4]. Open urethroplasty is also regarded as the gold-standard treatment of resistant urethral stricture disease [5].

The learning curve for several urologic [6–9] and nonurologic surgeries [10–12] was previously reported. However, the learning process for one-stage urethroplasty has never been addressed before. This is of utmost importance because the learning curve has relevant clinical implications for patient safety and surgical outcomes during the learning process [13].

With this in mind, we aimed to evaluate the first largest single-surgeon experience for one-stage anterior urethroplasty. We hypothesized that surgical experience has a significant impact on the probable success of the procedure. We evaluated the surgical learning curve for one-stage anterior urethroplasty in a large cohort of patients treated by a single surgeon over the last 2 decades.

2. Materials and methods

2.1. Patient population

The study cohort consisted of 641 consecutive patients treated with one-stage anterior urethroplasty for urethral stricture by a single surgeon (G.B.) between 1994 and 2014. Data were prospectively collected from the first case treated by the surgeon during his career. We therefore were able to analyze data on all the surgeon's patients throughout his career to date.

2.2. Surgical technique

All patients were treated with one-stage anterior urethroplasty using substitute tissues. Detailed information regarding our surgical technique for the treatment of both penile and bulbar stenosis was previously described [14–17]. One-stage penile urethroplasty was performed using either a free graft (penile skin vs oral mucosa) or a skin flap [14]. One-stage bulbar urethroplasty was performed using a free graft (penile skin vs oral mucosa) placed in either the ventral or dorsal urethral surface [15–17].

2.3. Definition of variables

All patients had complete clinical data that consisted of age at surgery, body mass index (BMI), smoking history (no, yes. ex-smoker), diabetes history (no or yes), etiology of stenosis (idiopathic, iatrogenic, infectious/lichen sclerosus related, or traumatic), and history of surgical treatments (including urethral dilation, endoscopic urethrotomy, or urethroplasty). Retrograde and voiding cystourethrography was performed preoperatively to assess stricture length and stricture site. Information regarding length of stenosis was obtained from the cystourethrography report and categorized as ≤3, 4, 5, or ≥6 cm, despite the continuous nature of the variable. At the same time, the site of stenosis was considered as penile, bulbar, or panurethral. For each patient, surgeon experience was coded as the total number of one-stage urethroplasties performed by the surgeon before the patient's operation.

2.4. Outcome definition

The outcome of the study was treatment failure, defined as any postoperative instrumentation needed (including dilation), according to previous studies [3,18–20].

2.5. Follow-up

Uroflowmetry and urine culture were repeated every 6 mo in the first 2 yr and annually thereafter. When symptoms of decreased voiding flow were present and uroflowmetry was <12 ml/s, retrograde and voiding urethrography, urethral ultrasound, and urethroscopy were repeated to fully document re-stricture features.

2.6. Statistical analysis

Our statistical analysis consisted of two steps. First, multivariable Cox regression analysis was used to evaluate the association between surgeon experience and treatment failure. Surgeon experience was entered as a continuous variable, using restricted cubic splines with knots at the tertiles to allow a nonlinear relationship between experience and failure. Covariates consisted of age, BMI, smoking history, diabetes history, history of surgical treatments, stricture length, and stricture site.

Second, to produce a learning curve, we calculated the probability of freedom from treatment failure at 5 yr after surgery predicted by the model for each level of surgical experience, using the mean value for covariates. Such probability was plotted against surgeon experience to obtain the surgical learning curve for one-stage urethroplasty.

All statistical analyses were performed using Stata software v.12 (StataCorp LP, College Station, TX, USA).

3. Results

Table 1 shows the descriptive characteristics of the patient population. Overall, 546 patients (85%) were treated with one-stage oral mucosa urethroplasty; penile skin or skin flap was used in 95 patients (15%). Overall, 514 (80%) had bulbar stricture, 101 (16%) had penile stricture, and 26 (4.0%) had panurethral disease. Previous treatments were administered to 529 patients (83%).

Median follow-up among patients who did not experience surgical failure was 69 mo (interquartile range: 35–118). The rate of freedom from failure at 5 yr was 74% (95% confidence interval [CI], 77–81).

At multivariable Cox regression analysis (Table 2), surgeon experience was significantly associated with a lower probability of treatment failure, after adjusting for case mix (hazard ratio [HR] per 20 procedures, without the nonlinear terms: 0.98; 95% CI, 0.97–0.99; p = 0.009).

Figure 1 illustrates the surgical learning curve for one-stage anterior urethroplasty. The predicted probability of freedom from treatment failure at 5 yr was plotted against surgeon experience. We observed a slight and progressive increase of treatment success, from 70% during the initial surgeon experience to approximately 85% after a large number of performed procedures. Interestingly, the relationship between the probability of surgical success and