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Original Research

Preliminary Application of a Novel Anatomic Urethroplasty Technique Using Everted Saphenous Vein Graft for Long Penile Urethral Strictures

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Abstract

Background: This paper reports two cases of anatomic urethroplasty (AU) using everted saphenous vein graft (eSVG) with long penile urethral strictures. The preliminary feasibility and safety of the operation are also analyzed. **Methods**: Two men with penile urethral strictures (5.5 cm and 5.0 cm) were treated with AU using eSVG. The highlight of this novel surgical technique was the anatomical repair of the layer of the narrowed urethral wall without affecting the continuity of the layer of corpus spongiosum. Moreover, the pre- and postoperative Urodynamics and Night Penis Tumescence and Rigidity test results were compared. **Results**: Complications, such as hematoma, urinary fistula, or urethral strictures, were not observed at 2 weeks postoperatively. At 6 months postoperatively, the urination status and urodynamic indexes of the patients had significantly improved compared with that preoperatively. There was no significant change in erection function before and after the operation. **Conclusions**: Repairing long penile urethral strictures with AU using eSVG is safe and feasible and can be used as an alternative treatment method.

Keywords: urethral stricture; everted saphenous vein graft; urethroplasty

1. Introduction

Urethral stricture is a relatively common disorder occurring in men, with an incidence of approximately 229–627 individuals per 100,000 [1]. Based on the etiology, urethral strictures can be categorized as congenital, traumatic, iatrogenic, and infectious. Trauma and infection are the most common reasons resulting in lower urinary tract symptoms, and these may be complicated by infection, stones, and renal insufficiency [2]. Due to the distinct anatomy and function of the urethra, treatment of these symptoms can be challenging, especially for long urethral strictures. For anterior urethral strictures, penile strictures are more difficult to treat compared to bulbar strictures, therefore success rate is lower. The success rate remains <50% even for the commonly used oral mucosal grafts for penile strictures [3].

Therefore, researchers have been in search of novel methods to treat long urethral strictures. El-Morsi *et al*. [4] used a saphenous vein graft (SVG) to repair long urethral strictures in the last century and achieved significant success. However, the success rate of using SVG or everted SVG (eSVG) remains unsatisfactory [5,6]. In their studies, the graft was anastomosed with the entire thickness of the urethra, resulting in the loss of corpus spongiosum on the outside of the graft. Disruption of the continuity of the layer of corpus spongiosum would lead to a poor healing process, and make it more likely to relapse into stricture. Therefore, we attempted to conduct anatomic urethroplasty (AU) using eSVG on two male patients with long penile urethral strictures. Consequently, we were able to restore the layer of the narrowed urethral wall without affecting the continuity of the layer of corpus spongiosum. The clinical history, management, and follow-up of these two patients have been described in this study.

2. Materials and Methods

2.1 Patients

Patient A, a 54-year-old male, was admitted to our hospital for poor urination and a 20-year history of urethritis. Specialized examination revealed that the distal corpus spongiosum was cord-like, about 5.5 cm long, hard in texture, and non-tender. The rest of the penile urethra was normal. B-mode ultrasound and computed tomography exhibited no abnormalities in the kidneys, ureter, and bladder. As per the results of the retrograde urethrogram, the penile urethra had narrowed, and the mucosa appeared incomplete with a length of 5.5 cm. However, the posterior urethral mucosa was intact, and the contrast agent passed smoothly during urination.

Patient B, a 43-year-old male, was admitted to our hospital for poor urination. Penile flap urethroplasty was conducted in another hospital 3 years ago because of penile urethral strictures. Specialized examination of the urethra showed a cord-like change at approximately 1.5 cm away from the external urethral orifice in the palpable urethra. It

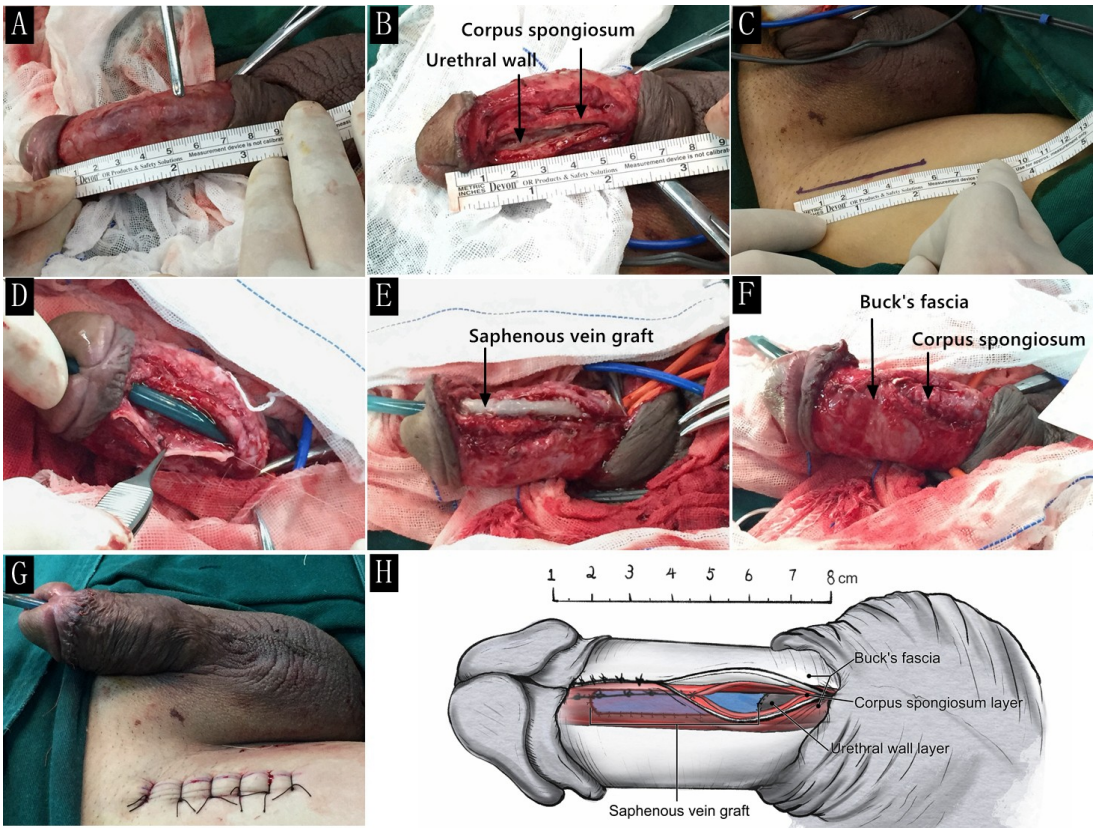

Fig. 1. Procedure for anatomic urethroplasty (AU) using everted saphenous vein graft (eSVG). (A) Expose the penile urethra, and measure the length of the segment of the urethral stricture (6-cm). (B) A longitudinal incision was made at Buck's fascia, the corpus spongiosum, and the urethral wall until the urethral lumen was exposed. (C) Harvest a 6-cm long blood vessel (the saphenous vein) from the inner side of the right thigh. (D) An F16 hydrophilic catheter was inserted and the free edge of the eSVG was anastomosed with the free edge of the urethral wall using a 6–0 absorbable thread. (E,F) The free edge of the incised corpus spongiosum (E) and Buck's fascia (F) was then re-anastomosed using a 4–0 absorbable thread. (G) The skin and superficial fascia layer were restored, and the incision was closed. (H) The hierarchy of the penile urethra in AU was displayed with an illustration.

was about 5.0 cm long, hard, and non-tender. The rest of the anterior urethra was normal. Retrograde urethral angiography revealed that the penile urethra had narrowed for approximately 5.0 cm from the external urethral orifice. The posterior urethral mucosa was intact, and the contrast agent passed smoothly during urination.

Both patients successfully underwent AU using eSVG at Zhongnan Hospital of Wuhan University. This study was performed in accordance with the ethical principles of the Declaration of Helsinki, and the patients provided written informed consent prior to inclusion

2.2 Surgical Method

AU was conducted under general anesthesia. A circular incision was made at approximately 0.5 cm below the coronal sulcus until it reached Buck's fascia. The skin and superficial fascia were then degloved to the root of the penis, which was temporarily ligated with an F5 red catheter. The surrounding tissues of the urethra were entirely freed to expose the penile urethra. After locating the segment of the urethral stricture, a longitudinal incision was made at Buck's fascia, the corpus spongiosum, and the urethral wall until the urethral lumen was exposed. The incision was covered with saline gauze. Subsequently, a 6-cm skin incision was made on the inner side of the right thigh, and the saphenous vein was freed and fully exposed. Both ends were then ligated to harvest a 6-cm blood vessel that was longitudinally severed, and the venous valve was removed and immediately immersed in papaverine solution (30 mg in 100 mL) for 5 minutes. Further, an F16 hydrophilic catheter was inserted through the external urethral orifice. With the lumen of the SVG facing outward, we anastomosed the free edge of the SVG with the free edge of the urethral wall using a 6–0 absorbable thread. Finally, the free edge of the incised corpus spongiosum and Buck's fascia was then re-anastomosed using a 4–0 absorbable thread. The hemostatic catheter was loosened at the base of the penis, and bleeding was carefully stopped. The skin and superficial fascia layer were reseated, and the incision was sutured. The penis was wrapped with gauze and elastic bandage to relieve edema. The detailed AU procedure is shown in Fig. 1.

Table 1. Pre- and postoperative urodynamics and erection function (n = 2).

Items		Urodynamics			NPTR[a]		
		MCC (mL)	Qmax (mL/s)	Pdet max (cmH_2O)	Tip Rigidity (%)	Base Rigidity (%)	Number of erection per night
Patient A	Preoperative	326	7.64	126.74	65.0	73.0	5.6
	Postoperative	351	16.16	64.57	63.0	75.0	5.4
Patient B	Preoperative	275	8.32	167.21	76.0	62.0	3.1
	Postoperative	287	12.59	78.35	75.0	65.0	3.9

Urodynamics was evaluated via Urodynamic Testing (94 Series Patient Recorder, UDS-94-BT, Laborie Medical Technologies Canada ULC; Mississauga, Ontario, Canada), and erection function was evaluated via NPTR testing (Rigscan® Plus, GOTOP Medical, Co., Ltd.; Saint Paul, Minnesota, USA).

[a]. Data are represented as mean.

MCC, maximum bladder capacity; Qmax, maximum flow rate; Pdet max, maximum detrusor pressure; NPTR, Night Penis Tumescence and Rigidity.

2.3 Observational Indices and Follow-Up

Urodynamics, retrograde urethrogram, and Night Penis Tumescence and Rigidity (NPTR) tests were all performed preoperatively and at 6 months postoperatively. The first two indices were used to assess the effectiveness of the AU procedure, while NPTR tests were used to assess whether the procedure affected erectile function. All patients underwent standardized urodynamic (94 Series Patient Recorder, UDS-94-BT, Laborie Medical Technologies Canada ULC; Mississauga, Ontario, Canada) and NPTR test (Rigscan® Plus, GOTOP Medical, Co., Ltd.; Saint Paul, MN, USA). Any complications such as hematoma, urinary fistula, or urethral stricture were carefully recorded.

3. Results

The catheter was removed 2 weeks postoperatively. The patients showed no abnormal reactions, such as frequent urination, urgency, painful urination, or hematuria. The wound healed well without hematoma, urinary fistula, or urinary incontinence. After 6 months, retrograde urethrogram showed that the urethra was unobstructed, the inner diameter was large, and there was no stenosis or diverticulum (Fig. 2). For the retrograde urethrogram of Patient B, please refer to **Supplementary Fig. 1**. The patient reported experiencing smooth urination without any dysuria and satisfaction with the appearance of the penis. Urodynamic analysis indicated that the patient's maximum bladder capacity (MCC) remained unchanged at 6 months postoperatively, but the maximum urine flow rate (Qmax) and maximum detrusor pressure (Pdet max) had improved significantly. The patient's symptoms of urinary obstruction were significantly improved. NPTR testing at 6 months postoperatively showed no significant changes in the average erection intensity and the duration and number of erections at night pre- and postoperatively. The operation did not affect the erection or perception function of the penis. Detailed information on the pre- and postoperative urodynamics and erection function are shown in Table 1.

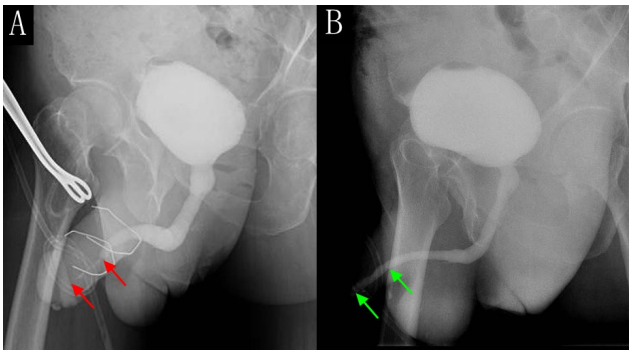

Fig. 2. Retrograde urethrogram of Patient A. (A) Preoperatively, the penile urethra was narrow (between the two red arrows), and the mucosa was incomplete for approximately 5.5 cm from the external urethral orifice. (B) Postoperatively, the urethra was unobstructed, the inner diameter was wide, and there was no stenosis or diverticulum (between the two green arrows).

4. Discussion

Urethral strictures are relatively common among men and can have different causes, mostly iatrogenic or traumatic. The total success rate of different treatment methods is approximately 8%–80% [7]. Currently, treatment for male urethral strictures mainly involves surgery, including intracavitary stricture incision/resection and open urethroplasty. However, for urethral strictures that are >3-cm long or are complex, clinicians are more inclined to repair the urethral strictures through grafting [8]. Although the grafts currently reported for urethral repair include oral mucosa, penial/scrotal/abdominal flaps, bladder mucosa, colorectal mucosa, and blood vessels, the success rate of repairing long urethral strictures is low. Even for the commonly performed oral mucosal repair, the success rate for strictures >7-cm long is only 40% [9–11]. Due to the development of bioengineering technology and stem cell biology, new discoveries and breakthroughs have been made in this field, but it will still take time before clinical application begins [12,13]. Therefore, ideal grafts and novel surgical methods

are being investigated to treat long urethral strictures.

Using SVG to repair urethral strictures was reported as early as 1972, and the effect is definite [4]. Later, Kim *et al*. [14] used a rabbit model to show that the SVG repair of urethral stricture is feasible. Li *et al*. [15] also published similar reports, confirming that SVG is safe and feasible. Moreover, many studies have shown that everted SVG (eSVG) is more effective than non-everted SVG. First, a rabbit immunohistochemical study [14] shows that regardless of the type of SVG (eSVG or non-eSVG), the luminal surface of the graft will be lined with urothelium, and the graft is only a stent for the nearby urethral epithelium to gradually crawl and grow toward the graft. Second, the key factor for successful reconstruction of the urethra is the rapid neovascularization of the graft to ensure sufficient blood supply. A study on Beagle dogs [15] found that the graft can be supplied with better nutrition via the surrounding tissues through the endothelium instead of the outer membrane. Therefore, the survival time of the eSVG is longer, so the newly formed epithelium will be better and smoother, and the incidence of fistula will be rather low. Additionally, eSVG can avoid the adverse effects of urethral valves on urine flow. Keeping these positive reasons in mind, we also used eSVG for AU.

The novel aspect of this study is the anatomical repair of the layer of the narrowed urethral wall without affecting the continuity of the layer of corpus spongiosum. The urethra includes an outer layer (corpus spongiosum) and an inner layer (urethral wall). The corpus spongiosum comprises abundant elastic and smooth muscle fibers that are capable of accommodating abundant sinusoids; the urethral wall comprises the muscular, submucosal, and mucosal layers from outside to inside. Notably, Akhtar [6] used eSVG to repair long (>7 cm) male penile urethral strictures and achieved good results. After 6 months, 13 of the 16 patients showed significant improvement in urination, the caliber of the penile urethra was good, and the success rate was as high as 80%. For the 3 cases of stenosis recurrence, our hypothesis is that the graft was anastomosed with the entire thickness of the urethra, resulting in the loss of corpus spongiosum on the outside of the graft and disruption of its continuity. The urethra lacks a complete hierarchical structure, which leads to a poor healing process, and makes it more likely to relapse into stricture and urinary fistula. Therefore, from an anatomical point of view, after we incise and distinguish the corpus spongiosum and the narrowed urethral wall during the operation, the free edge of the eSVG is first anastomosed with the free edge of the narrowed urethral wall, after which the incised corpus spongiosum is re-anastomosed. Because the corpus spongiosum is elastic and malleable, the re-anastomosed corpus spongiosum will not compress the urethral wall. In this manner, forming the inner mucosa of the eSVG will result in the restoration of the complete urethral hierarchy. Theoretically, the possibility of urinary fistula, restenosis, or secondary surgery is very low.

After 6 months of follow-up, the two patients in our study showed smooth postoperative recovery, significantly improved obstructive urination, and a Qmax of approximately 15 mL/s, which was close to normal. Complications such as swelling and fistula formation were not observed. The erection or perception function of the penis did not change postoperatively, and the postoperative satisfaction was high. In conclusion, our preliminary results showed that eSVG for AU to repair long penile urethral strictures is effective, safe, and feasible.

The present study has its limitations, including the small number of patients and the short follow-up duration. Although a large sample of long-term clinical follow-up is needed to understand the clinical value of this surgery, the purpose of our current study is to evaluate the early results as any innovative surgical technique has to go through the Idea, Development, Exploration, Assessment and Long-term follow-up (IDEAL) process to be used in clinical practice.

5. Conclusions

AU with eSVG is a viable option for repairing long penile urethral strictures with promising results and low adverse events. The promising clinical outcome of the procedure is attributed to the anatomical repair of the layer of the narrowed urethral wall without affecting the continuity of the layer of corpus spongiosum. In the future, more cases must be included, and a longer follow-up period is required to verify the safety and reliability of the procedure.

Author Contributions

Study Design: DLH, XJS. Data Collection: JHL, CHL, XHW. Data Analysis: CHL, YMG. Writing Original Draft: JHL, YMG. Manuscript Review and Editing: DLH, XJS. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

The study was approved by the Ethics Committee of Zhongnan Hospital of Wuhan University. (Approval Number: 2017110). This was a registered trial (ID: ChiCTR-INR-17012652; Time: 2017/09/12).

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/j.jomh1809189.

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