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ORIGINAL ARTICLE

Intrasphincteric anastomotic urethroplasty allows preservation of continence in men with bulbomembranous urethral strictures following benign prostatic hyperplasia surgery

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Abstract

Purpose Injury to the external sphincter during urethroplasty at or near the membranous urethra can result in incontinence in men whose internal sphincter mechanism has been compromised by previous benign prostatic hyperplasia (BPH) surgery. We present outcomes of a novel reconstructive procedure, incorporating a recent anatomic discovery revealing a connective tissue sheath between the external sphincter and membranous urethra, which provides a surgical plane allowing for intrasphincteric bulbo-prostatic urethroplasty (ISBPA) with continence preservation.

Methods Stricture at or near the membranous urethra after transurethral resection (TURP) or open simple prostatectomy (OSP) was reconstructed with ISBPA. The bulbomembranous junction is approached dorsally with a bulbar artery sparing approach and the external sphincter muscle is carefully reflected, exposing the wall of the membranous urethra. Gentle blunt dissection along this connective tissue plane allows separating the muscle away up to the prostatic apex, where healthy urethra is found for anastomosis.

Results From January 2010 to August 2019, 40 men (18 after TURP and 22 after OSP) underwent ISBPA at a single institution. Mean age was 67 years (54–82). Mean stricture length was 2.6 cm (1–6) with obliterative stricture identified in 10 (25%). At a mean follow-up of 53 months (10–122), 36 men (90%) are free of stricture recurrence and 34 (85%) were completely dry or using one security pad.

Conclusion This novel intrasphincteric urethroplasty technique for stricture following BPH surgery is feasible and safe, allowing successful reconstruction with continence preservation in most patients. A larger series and reproduction in other centers is needed.

Keywords Urethral stricture · Urinary incontinence · Transurethral resection of prostate · Urethra

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Introduction

Urethral strictures or stenosis following BPH surgery are not rare, with a post-operative incidence reported to be 1.1–4.1% [1–3]. Delayed stricture formation may be observed, with rates of 2.2–9.8% seen with extended follow-up after TURP [4].

Stenosis or stricture following BPH surgery can occur at any location, from bladder neck to meatus, with stricture of the bulbar urethra and fossa navicularis seen mostly commonly [4–6]. Prostatic or membranous urethral stenosis or proximal bulbomembranous stricture pose a particular reconstructive challenge in men following BPH surgery, because TURP or prostatectomy results in disruption of the internal sphincter mechanism, with urinary continence subsequently relying on the nearby external rhabdosphincter [7, 8]. Urethroplasty in this setting can result in injury of the external sphincter mechanism with high rates of urinary incontinence observed [9].

A 2008 cadaveric study advanced the understanding of the posterior urethral anatomy by identifying a delicate sheath of connective tissue separating the membranous urethra from the rhabdosphincter (Fig. 1a) [10]. The existence of this sheath, confirmed histologically and anatomically, inferred the feasibility of temporarily separating the sphincter muscle from the urethra.

Utilizing this discovery, the novel ISBPA urethroplasty technique was developed to preserve external sphincter function during urethroplasty. We hypothesize this technique is safe and can facilitate successful urethral reconstruction without a high rate of postoperative incontinence. Herein we examine the clinical outcomes of ISBPA in men with prostato-membranous stenosis or stricture of the proximal bulbar urethra following BPH surgery.

Methods

After institutional review board approval, a prospectively managed database including all male patients reconstructed at a single institution using ISBPA from January 2010 to August 2019 was reviewed. Patients with complete clinical data, known history of BPH surgery, and subsequent stenosis or stricture near or involving the membranous urethra were included. Patients with bladder neck contracture, a history of radiation or lichen sclerosus, preoperative urinary incontinence, or follow-up < 10 months were excluded.

Patient variables for analysis included demographic data, BPH-surgery type, prior urethral procedures, urethral stricture length, presence of obliterative disease, operative time, associated operative techniques utilized, and post-operative complications**.** Stricture location was classified with urethrography, with obstruction identified in three patterns: isolated membranous stricture, membranous urethral stenosis extending into the prostatic urethra (prostato-membranous), and proximal bulbar stricture near or extending into the membranous urethra (bulbomembranous urethral stricture, BMUS) (Fig. 2).

The primary study outcome was reconstruction failure, defined as the appearance of obstructive voiding symptoms from recurrent stricture requiring invasive studies (urethrography or cystoscopy) and/or invasive treatment (dilation, internal urethrotomy, or urethroplasty). A secondary outcome of postoperative urinary incontinence, defined as subjective incontinence reported by the patient or the need to wear more than a single daily security pad, was also evaluated.

Preoperative investigations

A detailed history and exam identified patients with stricture or stenosis following BPH surgery. Importantly, both fluoroscopic retrograde urethrography and voiding cystourethrography as an "up and down" study were obtained in all patients to clearly demarcate the stricture extent and location. Urethroscopy evaluated the quality of the urethra and proximity to the sphincter and was performed through the suprapubic catheter site in obliterative cases. Urinalysis and culture were routinely obtained.

Intrasphincteric bulbo-prostatic anastomosis technique

Exposure and mobilization of the bulbar urethra is performed in a non-transecting fashion without detachment from the perineal body. Splitting of crura is performed as necessary. The urethra is retracted laterally with vessel loops. The bulbar vessels are identified and retracted posteriorly in a bulbar artery sparing approach (Fig. 1b) [11, 12].

The membranous urethra is secured with a fourth vessel loop. The sheath is opened circumferentially at the bulbomembranous junction, carefully reflecting the circular muscle fibers of the external sphincter to expose the urethral wall (Fig. 1c). When the connecting tissue plane is identified, gentle blunt dissection proximally allows gradual separation of the muscle from the urethra up to the prostatic apex, where healthy urethra is identified for anastomosis (Fig. 1d, e). To minimize risk, bipolar cautery is used for hemostasis and extreme care is taken when manipulating the muscle.

The anastomosis is performed with at least six 5–0 poliglecaprone sutures at the prostato-membranous junction, taking care not to include the muscle within the suture.

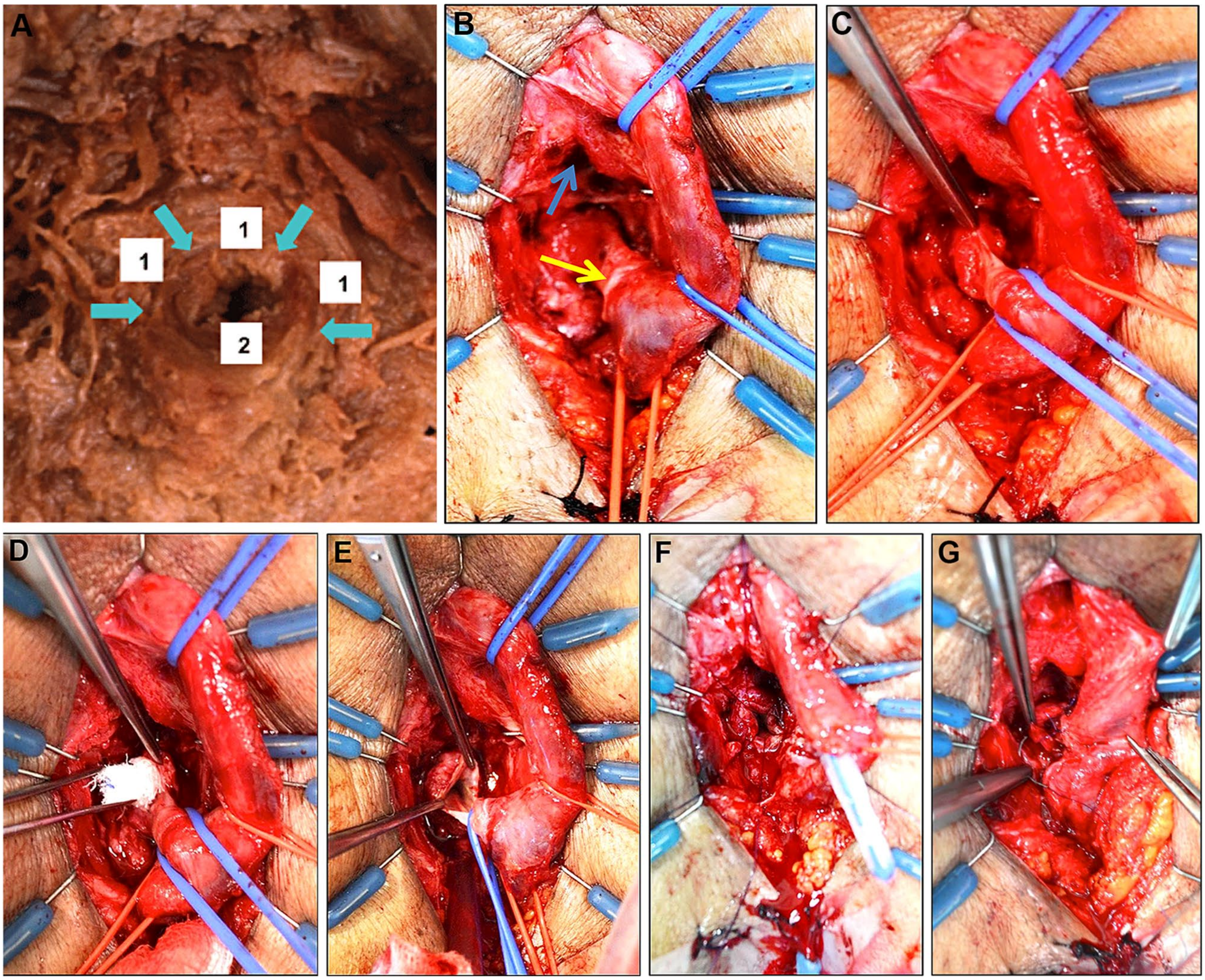

Fig. 1 **a** Anatomical specimen of the male rhabdosphincter, the urethra, and the neurovascular bundles (caudal view). The rhabdosphincter (1) forms an omega-shaped loop around the membranous urethra (2). A delicate sheath of connective tissue is located between the rhabdosphincter and the urethra (marked with arrows). Reprinted with permission, BJU International, Volume: 102, Issue: 10, Pages: 1448–1451, First published: 23 October 2008, DOI: (10.1111/j.1464-410X.2008.07772.x). **b** The bulbar urethra has been mobilized and retracted laterally to two vessel loops (blue). The bulbar vessels are retracted posteriorly with another vessel loop (red). The intercrural space has been divided (blue arrow) and the edge of the divided perineal membrane is visible at the bulbomembranous junction (yellow arrow). **c** A circumferential incision has been made at the bulbomembranous junction, the urethral wall is exposed, and the surgical plane is identified. Forceps hold the muscle ring of the external sphincter. **d** Gentle blunt dissection is performed to separate the sphincter from the urethral wall. **e** The proximal end of the urethra is exposed with a wide caliber noted. **f** Anastomotic stitches are placed in the normal urethral wall. **g** The spared external sphincter is anchored with suture back to the urethra at the anastomosis

Since the bulb is not detached, lateral sutures need to be transferred contralaterally to tie the anastomosis in a parachute fashion (Fig. 1f). A 16 French silicone Foley catheter is passed and, after knot tying, the ring of sphincter muscle is anchored back to the urethra at the anastomosis site with three or four interrupted sutures (Fig. 1g).

Postoperative evaluation

Follow-up visits were scheduled at 1, 3, 6, and 12 months postoperatively and annually thereafter. The urethral catheter remains for 3 weeks when voiding cystourethrography is utilized to assess for extravasation. Patients reporting incontinence are given specialized pelvic floor kinesitherapy. Postoperative urinary continence was defined as patient satisfaction with urinary control without the need of pads or use of a single safety pad only. Stricture recurrence was ruled out by either a Qmax $\geq$ 15 ml / sec, an IPSS $\leq$ 7, or by passage of a 16 French flexible cystoscope at most recent office visit.

Follow-up was successfully updated 6 months prior to publication in person or by phone call in 37 cases. Three patients were unable to be reached. One was lost

Fig. 2 Urethrogram images representing post-BPH surgery stricture locations. **a** Retrograde urethrogram (left) and voiding cystourethrography (right) demonstrating BMUS in a patient later repaired with ISBPA. This stricture could also have been amenable to ventral grafting procedure. **b** Voiding cystourethrogram studies prior to ISBPA in different patients identifying proximal stricture with prostatomembranous involvement that may not be amenable to ventral graft repair. **c** Combined urethrogram and cystogram showing obliterative disease that necessitated anastomotic reconstruction with ISBPA

to follow-up but was voiding normally with a Qmax of 28 ml/sec at a 37-month visit, another was institutionalized with dementia but voided satisfactorily at 51 months, and the last was voiding normally at 29 months postoperatively but passed away from unrelated causes.

Statistical associations were assessed with Stata SE, version 13.0 (StataCorp, College Station, TX). Univariate associations with the primary and secondary outcome were assessed with two-sided Student's t test for continuous variables and the Fisher's exact test for categorical variables. A p value < 0.05 was considered to be statistically significant.

Results

Forty patients underwent ISBPA from January 2010 to August 2020 and were included for analysis. All had severely symptomatic obstruction from prostate-membranous stenosis ($n = 8$, 20%), membranous stenosis ($n = 1$, 2.5%), or BMUS ($n = 31$, 77.5%) on evaluation following BPH surgery. Mean time from causative surgery to reconstruction was 14 months (1–152).

The mean stricture length was 2.6 cm (1–5), and 3 men with BMUS experiencing stricture extending 3 cm into the bulbar urethra. Ten patients (25%) had complete urethral obliteration, with a median obliteration length of 3 cm. In total, 13 cases (35%) presented with prostato-membranous or obliterative strictures. Seventeen patients (43%) required a suprapubic catheter.

Twenty-five patients (63%) had undergone previous endoscopic management of their urethral stricture including multiple dilations in 11, a single direct vision internal urethrotomy in 8, and 4 patients undergoing ≥ 2 endoscopic procedures.

A bulbar artery sparing procedure was successful in all. Crural separation was performed in 33 patients (82.5%), and inferior pubectomy was not required in any.

At a mean follow-up of 53 (10–122) months, ISBPA success was observed in 90%. The characteristics and outcomes of the 4 men experiencing stricture recurrence are detailed in Table 1, with no significant associations with reconstruction failure identified ($p > 0.05$, data not shown).

Urinary continence was reported in 34 (85%) patients, while 6 reported significant stress incontinence requiring 2–4 pads daily. Eight of the continent men continued to use a single safety pad, while 26 reported being completely dry. No patient demographics or surgical characteristics were associated with postoperative incontinence on univariate analysis (Table 2). Surgical implantation of an ATOMS device in 2 patients resulted in resolution of their incontinence. Another 4 reported tolerable, mild incontinence and did not pursue further surgery.

Significant complications included a scrotal hematoma requiring drainage under anesthesia (Clavien grade IIIb) in one and coronary artery stenting on postoperative day 26 (Clavien IV) in another.

Discussion

The novel intrasphincteric urethroplasty described herein was first conceived of and performed by co-authors RGG and RAS in 2010. Reasonable success rates (90%) and avoidance of incontinence (85%) following 10 years of experience with the technique are reported. The procedure appears safe, with minor complications (hematuria, small hematomas, or catheter dislodgement or obstruction) in 15% and two cases of Clavien grade ≥ III complications.

Anatomy and physiology of continence following BPH surgery

Anterior urethral stricture rates as high as 9.8% have been reported following monopolar TURP [4], and stricture rates do not appear to be improving in the era of more advanced endoscopic technology. Randomized trials comparing endoscopic BPH surgery utilizing bipolar cautery or laser

Table 1 Characteristics of patients with stricture recurrence following ISBPA

ISBPA Date	Age (years)	CCI	BPH surgery	Time to reconstruction (months)	Previous procedures	Stricture length (cm)	Location	Obliterative	Recurrence time (months)	Management	Outcome
2015	73	1	TURP	121	DVIU × 2	1	Bulbomembranous	No	15	Dilation × 1	Voiding catheter free
2015	54	0	TURP	21	DVIU × 2	4	Bulbomembranous	No	13	DVIU × 1	Performs monthly self-dilation
2017	71	1	OSP	8	Dilations (multiple)	3	Bulbomembranous	No	8	Dilation × 1	Voiding catheter free
2019	63	1	OSP	14	Dilation × 3	3	Prostatomembranous	Yes	12	Dilation × 1	Voiding catheter free

Table 2 Patient characteristics by continence outcome following ISBPA

	Continent ($n=34$)	Incontinent ($n=6$)	All ($n=40$)	p
Characteristics				
Age, mean	66	67	65	0.73
Charlson Comorbidity Index, n (%)				
0	22 (65)	5 (83)	27 (67)	0.64
≥ 1	12 (35)	1 (16)	13 (33)	
Surgery, n (%)				
TURP	16 (47)	2 (33)	18 (45)	0.67
Open prostatectomy	18 (53)	4 (67)	22 (55)	
Stricture length in cm, median (range)	2.5 (1–6)	3.3 (2–5)	3 (1–6)	0.07
Urethral dilation or DVIU, n (%)				
None	11 (32)	4 (66)	15 (37)	0.07
1	3 (9)	1 (17)	4 (10)	
≥ 1	20 (49)	1 (17)	21 (53)	
Stricture location, n (%)				
Bulbomembranous	28 (90)	6 (67)	34 (85)	0.12
Prostato-membranous	3 (10)	3 (33)	6 (15)	
Complete obliteration, n (%)	8 (24)	2 (33)	10 (25)	0.63
Months to reconstruction, median (range)	18 (1–151)	6.5 (2–60)	14 (1–151)	0.19
Outcomes				
Operative time in minutes, mean	152	180	155	0.11
Complications, n (%)				
Clavien ≤ II	6 (18)	1 (17)	6 (15)	1.00
Clavien ≥ III	1 (3)	0	2 (5)	
Stricture recurrence, n (%)	4 (12)	0 (0)	4 (10)	1.00

enucleation have shown no difference in stricture rates, [13, 14] indicating this complication following BPH surgery will continue to be a problem faced in the modern reconstructive urologic practice.

Repair of proximal strictures near or involving the membranous urethra represents a significant challenge in the patient with previous bladder neck disruption. While the internal lissosphincter and external rhabdosphincter typically coordinate tonic and voluntary urinary continence, respectively, passive continence can be maintained by both mechanisms alone following disruption or injury to either sphincter [15]. This mechanistic overlap is why injury to nearby nerves or sphincter muscle during proximal urethral reconstruction can occur without affecting continence, [16] but this would prove risky in the setting of prior TURP or other bladder neck insult. TURP, OSP, or other BPH surgery involves transection of the bladder neck and the associated internal sphincter mechanism, with subsequent urinary continence becoming reliant on an intact rhabdosphincter [8].

The external rhabdosphincter is typically 2 cm in length and, rather that encompassing the membranous urethra circumferentially, is configured into an omega-shaped ring of muscle with a paucity of muscle fibers ventrally [17]. Understanding of the anatomy and physiologic principles of the male urinary sphincter and posterior urethra continues to evolve and remains a matter of debate [18, 19]. Our results illustrate how a relatively recent revelation regarding the relationship of the external sphincter with the membranous urethra has allowed for the development of the novel intrasphincteric urethroplasty technique [10]. In this study we present the clinical outcomes of this technique and corroborate the existence of this anatomic plane separating the external sphincter and membranous urethra, initially described in 2008 [10].

Medical knowledge is expanding at a rapid pace, but clinical practice lags scientific discovery by up to 17 years [20]. While the growing gap between scientific discovery and patient care is a universal problem, barriers to translational research are particularly prevalent in healthcare systems with limited resources [21, 22]. This publication is the first to report in vivo confirmation that male urinary sphincter function can be preserved following surgical development and temporary displacement of the rhabdosphincter muscle. It represents a successful translation of a basic research discovery into clinical practice, and improves our understanding of lower urinary tract anatomy and function.

ISBPA allows reconstruction of complex strictures not amenable to oral mucosa graft procedures

Our technique relies on separation of external sphincter muscle fibers away from the urethral wall, allowing access to the urethra for anastomotic reconstruction. However, this is not the only modified urethroplasty technique reported in this population of patients at risk for postoperative incontinence. In 2019, Barbagli et al. reported results of a modified, ventral onlay buccal mucosa graft (BMG) urethroplasty in 69 patients with post-TURP proximal bulbar urethral stricture located near the membranous urethra [23]. The technique incorporates a modification on the ventral BMG onlay, as described by Morey and McAninch [24], which is frequently utilized for proximal bulbar strictures. The technique specifically avoids lateral or dorsal dissection to minimize injury to the omega-shaped sphincter muscle, and instead utilizes a urethral incision ventrally, where the muscle fibers are deficient.

The stricture is first accessed through a ventral urethrotomy during their technique. Wide dilation over a wire is performed. Reconstruction is performed by securing BMG onto a ventral urethrotomy defect, made with an ophthalmic scalpel, with the proximal anchoring sutures placed just distal to the verumontanum [23].

The authors of this multi-institutional series report a stricture recurrence rate in 16%, with 5 of the 11 failures requiring periodic dilation or an indwelling catheter following failed repeat urethroplasty or urethrotomy. Despite the complexity associated with post-TURP sphincter strictures, this failure rate is similar to rates reported in other urethroplasty series utilizing a BMG technique [25]. This does represent a slightly higher stricture recurrence rate when compared to our series (10%). Comparison of the series may be limited by our smaller sample size (40 vs. 69 patients), but a comparable median stricture length (3 vs. 4 cm) and follow-up times (53 vs. 52 months) were observed. Additionally, our approach utilizes a primary excision and anastomosis technique which is associated with high success rates when compared to urethral reconstruction with grafting [26, 27].

However, the postoperative incontinence rate in our series was higher than that reported by Barbagli et al. (15% vs. 4%). A higher rate of incontinence may be related to more direct manipulation of the external sphincter, which could result in technical injury to the muscle or nerve structures that facilitate urethral compression. Barbagli et al. avoid handling of the sphincter altogether by performing urethrotomy and grafting in the ventral position, where the muscle fibers are deficient. Comparison of the incontinence rates in the two series may be limited for multiple reasons. The majority of patients in our series had a history of OSP (55%), whereas the Barbagli et al. series included only patients with a history of endoscopic BPH procedures which may not be equally at risk for incontinence. Specifically, their series includes an unspecified number of patients with stricture following transurethral incision of the prostate which may result in only limited internal lissosphincter dysfunction. The ventral grafting technique will only allow reconstruction of strictures whose proximal extent is not into the prostatic urethra, and it cannot be utilized in obliterative disease. Conversely, 35% of our series presented with either prostato-membranous or totally obliterative stenosis, suggesting these may be more complex cases with a potential for higher risk of external sphincter mechanism injury. The Barbagli et al. series excluded patients without complete clinical data or follow-up, whereas no patients in our prospectively managed series were lost to follow-up.

Clinical decision making for Post-BPH surgery sphincter strictures

ISBPA or the modified ventral onlay approaches are both technically demanding and best utilized by reconstructive urologists with significant experience. Especially long BMUS extending distally may not be amenable to an anastomotic technique, in which case ventral onlay urethroplasty is more appropriate. Alternatively, ISBPA has the advantage of allowing reconstruction of more complex prostato-membranous or obliterative strictures. An endoscopic approach utilizing urethrotomy has been advocated for trans-sphincteric obliterative strictures [28], which will be more prone to stricture recurrence than ISBPA. A history of numerous endoscopic procedure failures was common in our series, with 13 patients (35%) referred for reconstruction 3 or more years following their initial operation.

Recognition of the incontinence risk in stricture patients with a history of BPH surgery is critical, and appropriate counseling preoperatively is advisable. Referral of these patients to high volume centers is prudent. Our study is limited to results from a single institution with a heavy volume in urethral reconstruction, and reproducibility has not been demonstrated. It is our belief the technique can be successfully adapted into the practice of the reconstructive urologist with sufficient training and experience. This has proven to be the case with the bulbar-artery sparing technique which has been successfully utilized in multiple centers internationally [29]. Additional limitations of our study include a limited number of patients assessed and a lack of adequate control for comparison.

Conclusions

Our intrasphincteric anastomotic urethroplasty technique for prostato-membranous or bulbomembranous urethral stricture following BPH surgery is feasible and safe, allowing reconstruction of these complex strictures with continence preservation in most patients. A larger series with reproduction in other centers is needed.

Author contributions RGG – Protocol/project development, Data collection and management, Manuscript writing/editing. LGV – Data collection and management. RAC – Data collection and management. AAS – Data collection and management. EJD – Data collection and management. RAS – Protocol/project development, Manuscript writing/editing. KAS – Data management, Data analysis, Manuscript writing/editing.

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Compliance with ethical standards

Conflict of interest None of the authors have any conflict to disclose.

Human and animal rights and informed consent This study includes human subjects and was performed in accordance with all applicable ethical standards including the Helsinki declaration and its amendments, institutional/national research committee standards, and international/national/institutional guidelines.

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