Sexual function after anterior urethroplasty: a systematic review

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Background: Urethral surgery outcomes are often evaluated by assessing urinary flow and urethral patency. However, sexual consequences may appear after urethroplasty, impairing quality of life and patient's perception of success.

The aim of this study is to assess the relationship between anterior urethral reconstruction and postoperative sexual dysfunction, including the proposed factors predicting sexual outcomes.

Methods: We searched in PubMed database using the terms: "anterior urethroplasty", bulbar urethroplasty" or "penile urethroplasty", and "sexual dysfunction", "erectile function" or "ejaculation". Articles were independently evaluated for inclusion based on predetermined criteria. Systematic data extraction was followed by a comprehensive summary of evidence.

Results: Thirty-eight studies were included for final analysis. No randomised trial on the topic was found. Urethral surgery might affect different aspects of sexual function: erectile function, ejaculatory function, penile shape and length, and genital sensitivity, leading to severe sexual dysfunction. Patient perception of sexual impairment was related to post-operative satisfaction.

Conclusions: Sexual dysfunction after anterior urethral reconstruction is an important issue that must be appropriately discussed during preoperative patient counselling. Reported outcomes after anterior urethroplasty should include sexual consequences and relevance, evaluated using validated tools.

Keywords: Urethra; stricture; urethroplasty; sexual function; erectile dysfunction (ED)

Introduction

Urethral stricture has an estimated prevalence of 229–627 cases per 100,000 males (0.6% of susceptible populations in the United States) (1). According to recent European studies, urethral stricture disease affects men of all ages,

with a mean age at diagnosis of 46 years (range, 1–85 years) (2,3). Urethroplasty is the most definitive treatment for anterior urethral strictures, reaching successful outcomes in up to 98% of patients (4).

In the urethral reconstruction field, the concept

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of success was historically defined as the avoidance of secondary procedures. Recently, interest has shifted towards patient satisfaction. Patient-reported outcome measures (PROMs) have been developed for addressing both micturition and sexual function (5).

Any sexual dysfunction (SD) or genital complication related to urethral reconstruction could impact quality of life, and patient satisfaction after surgery, even if the procedure is considered "successful" and a patent urethra is achieved. These aspects must be considered and discussed at the time of preoperative patient counselling.

The aim of the present review is to summarize the impact of male anterior urethral reconstruction over postoperative sexual function, including erectile function, ejaculation, penile size, penile curvature, and genital sensitivity. Possible factors predicting sexual outcomes were additionally discussed. We present the following article in accordance with the PRISMA checklist (available at: http://dx.doi.org/10.21037/tau-20-1307).

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement criteria were followed for our review (6). The inclusion and exclusion criteria were determined prior to the literature search.

PubMed database was searched using the terms: "anterior urethroplasty", "bulbar urethroplasty" or "penile urethroplasty", and "sexual dysfunction", "erectile function" or "ejaculation". A detailed search of further relevant literature was conducted in the bibliography of the selected papers.

The eligibility criteria included English-language studies, on male patients older than 18 years old, who underwent any type of anterior urethroplasty. No publication year restrictions were applied.

Case reports with less than 10 patients were excluded. We also excluded studies focused on posterior urethroplasty, pelvic fracture related urethral injuries, primary hypospadias repair, or permanent perineal urethrostomy.

Our initial search found 141 articles (*Figure 1*). The titles and abstracts were screened by two independent authors and 48 articles were selected for potential inclusion. An additional 14 articles were included from searching the references of the selected articles. Full text articles were retrieved for all selected references. After independent review, articles were excluded if they did not meet inclusion criteria or did not contain relevant information on the topic.

In case of disagreement, a third reviewer would decide whether the study should be included.

Finally, 38 articles were included. Data extraction was done independently by two reviewers. Information extracted from the selected articles included:

- ❖ Study dates;
- ❖ Prospective or retrospective study design;
- ❖ Mono or multicentric study;
- ❖ Number of patients;
- ❖ Location of the strictures;
- ❖ Mean stricture length;
- ❖ Type of urethroplasties performed;
- ❖ Length of follow-up;
- ❖ Percentage of patients with *de novo* ED after urethroplasty;
- ❖ Whether a standardized questionnaire was used to assess ED;
- ❖ Whether or not patients were questioned about erectile function (EF) before their operation;
- ❖ Whether patients were questioned about ejaculatory function and whether a standardized questionnaire on ejaculation was used;
- ❖ Whether penile curvature, or shortening was evaluated;
- ❖ Whether cold glans and penile sensitivity was evaluated;
- ❖ Whether patient satisfaction was specifically evaluated.

Results

Evaluation of SD

SD after urethroplasty includes several disorders related to the sexual health that may arise after urethral repair such as erectile dysfunction (ED), ejaculation dysfunction (EjD), penile curvature, penile shortening, or genital sensitivity disorders.

Mundy *et al*. were the first to report ED after urethroplasty in 1993. They described a 5% permanent ED after anastomotic urethroplasty (AU) and 0.9% after patch urethroplasty in a series of 200 patients (7). After their report, numerous other studies have assessed the topic.

According to a metanalysis by Blaschko *et al*. in 2013, the reported incidence of ED after urethroplasty is 1%, however, available data are heterogeneous, ranging from 0% to 40% of postoperative SD (8). In fact, it is difficult to compare results among different studies as they evaluate
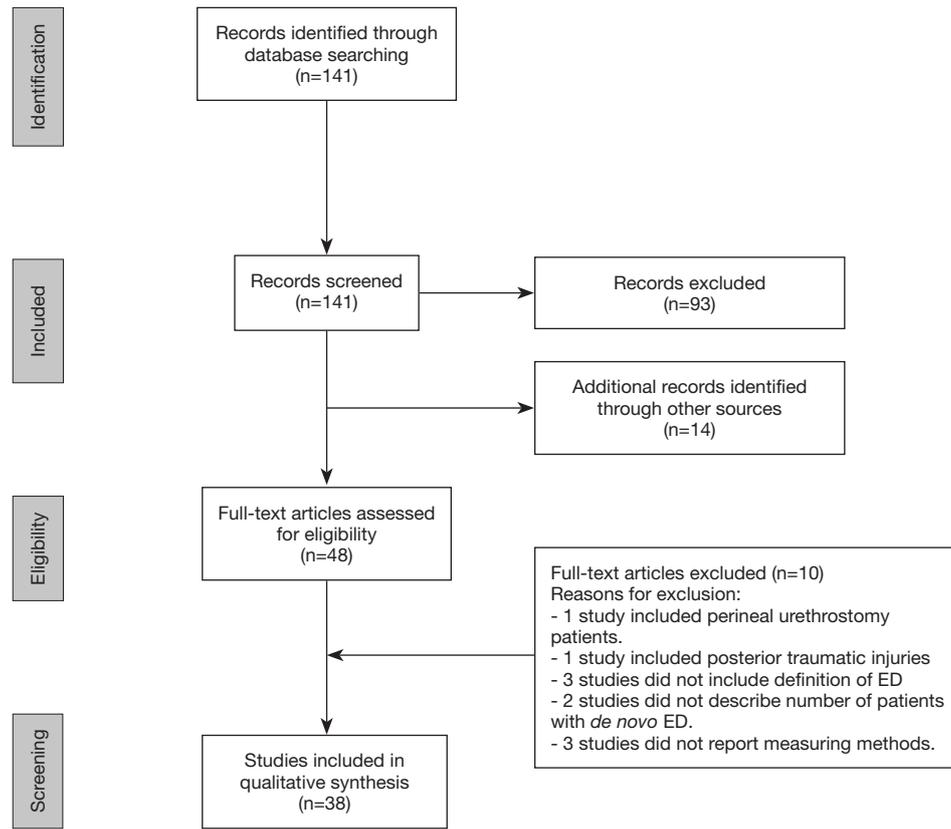
Figure 1 PRISMA flow diagram. ED, erectile dysfunction.

patients using different tools. Over the years, published reports have changed from direct questions about sexual problems towards a more objective assessment of SD, using validated questionnaires and including a preoperative assessment of baseline sexual function.

Below, we describe the most frequent questionnaires used to evaluate SD. However, none of these questionnaires are specific for post-urethroplasty patients.

❖ International Index of Erectile Function (IIEF) (9): validated self-administered 15-items questionnaire evaluating 4 domains: erectile function (Q1–5, Q15), orgasmic function (Q9–10), sexual desire (Q11–12), intercourse satisfaction (Q6–8) and overall satisfaction (Q13–14). Each question is answered in a 0–5 scale, to a maximum of 75 points.

❖ Sexual Health Inventory for Men (SHIM or IIEF5): modified 5-item version of the IIEF, designed to assess the presence and severity of ED according to specified benchmarks.

❖ O'Leary Brief Male Sexual Function Inventory (BMSFI) (10): a 11-question questionnaire that

rates from 0–4 the following items: sexual drive, EF, ejaculation, problem assessment and overall satisfaction. There are no defined benchmarks for this questionnaire, so it is difficult to state the clinical relevance of a certain decline.

❖ Male Sexual Health Questionnaire (MSHQ) (11): 25-item self-administered questionnaire that evaluates erection, ejaculation, and satisfaction. Some authors used ejaculation items as an independent questionnaire, as it provides a detailed evaluation of the topic (MSHQ-EjD).

Palminteri *et al.* laid emphasis in the importance of preoperative counselling (12) for patients, especially regarding the sexual health consequences of surgeries. In a study evaluating the outcomes of ventral buccal mucosa graft (BMG) urethroplasty, 73% of patients declared a medium/high anxiety degree tackling urethroplasty, and 27% denied having been adequately informed regarding possible sexual complications after their surgeries. Regarding the most relevant fears before undergoing urethroplasty, 85% declared being afraid that surgery might

not resolve their problem, 35% said they were afraid of a postoperative worsening in the quality of sexual life and 31% reported to be afraid of postoperative genital scars.

ED after anterior urethroplasty

Aetiology of ED

De novo ED after anterior urethral repair may have a neurogenic or vascular origin due to:

- ❖ Injury to the bulbar arteries or cavernosal-spongiosal branches during mobilization or transection of the bulbar urethra.
- ❖ Injury to the cavernous nerves during intercrural dissection of the urethra. These nerves run at 1 and 11 o'clock positions close to the proximal bulbar urethra (13).
- ❖ Injury of the perineal nerve; it rises from the pudendal nerve at the ischiorectal fossa and travels alongside the ischiocavernous and bulbospongiosus muscles (14). It extends branches that innervate the bulbospongiosus muscle, and contributes to innervation of corpus spongiosum, which may be important in erection, although the mechanism is unclear. The perineal nerve continues on the ventral side of penis giving sensory branches to innervate the ventral side of the penis, including the frenular area.
- ❖ Interaction between perineal nerves and penile dorsal nerves was observed by Yucel and Baskin (15), suggesting this interaction may be responsible for some unexplained neural reflexes causing erection, orgasm and ejaculation.

Psychosomatic factors may also play a role in the onset of ED. Coursey *et al.* (16) found that 27.3% of the patients related worsened erections after circumcision in otherwise healthy controls. They suggest that alterations in penile appearance could affect short-term sexual performance.

Predictive factors for ED after anterior urethroplasty

Factors such as age, stricture location, length of stricture and procedure have been proposed to affect sexual function after urethroplasty.

Age at the time of the urethroplasty

Erickson *et al.* (17) used BMSFI to evaluate SD after urethral reconstruction. They found that patients older than 50 years, experienced a significant decline in mean EF domain, contrary to younger patients.

Likewise, Anger *et al.* (18) suggested that age and

preoperative EF may adversely affect postoperative sexual outcome. In their prospective review, men with a postoperative score ≤20 in EF domain of IIEF questionnaire were older (mean age 47 *vs.* 36.8 years, P=0.17) and had worse preoperative EF values (mean 20 *vs.* 29, P=0.11) than those with postoperative EF scores >20, although the differences did not attain statistical significance.

Other authors did not find any association between age and occurrence of ED (19-21), although data showed that older men had lower preoperative IIEF scores and a greater decline in IIEF values (19,22). On multivariate analysis, Chapman *et al.* (21) did not find an association between age and SD.

Length of stricture

Coursey *et al.* (16) proposed length of stricture as a predictive factor, as they reported men with worse postoperative EF having a significantly longer stricture than those with improved or unchanged erection (mean 6.8 *vs.* 4 cm). However, further studies contradict this association (17,21,23).

Location of stricture

In a subanalysis of men with normal preoperative EF, Erickson *et al.* (24) revealed an overall postoperative ED of 66%, corresponding to bulbar repairs in 16 (76%) cases and to penile urethroplasties in 3 (38%). It is important to note that all but 2 men returned to their baseline EF after a median of 6 months.

Pfalzgraf *et al.* (25) did not find statistically significant differences between penile and bulbar groups regarding EF median score (26.5 *vs.* 14; P=0.47) or intercourse satisfaction median score (9.5 *vs.* 0; P=0.13). However, a difference between groups can be suspected. The size of the cohort could explain the difficulty to demonstrate statistical significance.

In contrast, Haines *et al.* (22) reported that stricture location was not associated with change in EF when examining both incidence of adverse change (defined as a change in IIEF-EF domain ≥5) (20.3% *vs.* 21.7%; P=1.0) and mean change (+0.95 *vs.* −2.74; P=0.18).

Erectile function after different surgical techniques

Penile strictures can be managed by flap or graft urethroplasties. Over the years, grafting has been the choice for penile repair, with a reported ED between 4–19% (16,19), although it was transient in most cases. In the case of penile flaps, Coursey *et al.* (16) reported 40% of worsened postoperative EF in their series of 44 patients.

Although AU are mostly used in bulbar urethra, Shakir *et al.* (26) stated that AU has a high success rate and good

sexual outcomes in short strictures in the pendulous urethra, especially in traumatic origin. In their small series, all patients reported stable EF, with median postoperative IIEF5 score of 21 (IQR: 19–25) after a median follow up of 43 months.

Staged urethroplasty with BMG offers high success rates for patients with complex penile strictures. However, sexual outcomes in this specific population are scarce. Patel *et al.* (27) reported a median SHIM postoperative score of 23 (IQR: 19–25) in these patients. No significant SHIM score difference from preoperative baseline was found at a median follow-up of 6.3 months after second stage surgery. Only 1 (4%) patient required ED medications postoperatively.

Bulbar strictures can be managed by anastomotic techniques—with or without complete transection of the corpus spongiosum- or augmentation urethroplasties, most frequently using BMG. The consequences over the sexual function of these two different approaches have been extensively discussed.

The excision and primary anastomosis technique (EPA) is characterised by complete transection of the urethra and extensive mobilization of bulbar segment in order to accomplish a tension free anastomosis. It is normally indicated for short obliterative strictures. However, some authors have challenged the indication for longer strictures. Morey *et al.* (28) presented a series of 22 men who underwent EPA for short (≤2.5 cm) or long strictures (>2.5 cm). An EF questionnaire was administered at 6 months postoperatively. Men in the longer stricture group had no increased rate of stricture recurrence or erectile complaints compared to men with shorter strictures. Complete loss of erections was reported in 2 patients from short stricture group and in none of >2.5 cm.

Barbagli *et al.* (29) investigated postoperative sexual disorders associated with bulbar EPA through a non-validated questionnaire administered by phone calls in 60 patients. Most of them had a stricture <3 cm (97.4%). No patient complained of *de novo* ED.

D'Hulst *et al.* (30) used IIEF5 to assess EF in 23 sexually active patients who underwent EPA. Patients were evaluated at 3 different times postoperatively. Fifteen patients with mild or no baseline ED (IIEF5 >17) had a significant decline in EF at 3 months follow-up (IIEF5: 23.27 *vs.* 13.91; P=0.002). This impairment remained significant at 6 months but was recovered by 18 months (23.25). Patients with moderate to severe ED (IIEF5 <16) at baseline experienced no significant difference in EF at any time point.

In an effort to avoid injuries to bulbar vessels during EPA, non-transecting techniques were developed. The original idea of a vessel sparing technique in AU was described by Jordan *et al.* in 2007 (31), specifically dissecting bulbar arteries off the urethra to preserve them. Later, Andrich and Mundy (32) described the non-transecting anastomotic bulbar urethroplasty (ntAU). Contrary to Jordan's technique, they avoid dissecting the bulb of corpus spongiosum from the perineal body. The ntAU is based in a dorsal stricturotomy, excision of urethral stricture with surrounding spongiofibrosis, but leaving healthy ventral spongiosum intact. The ventral aspect is then sutured and dorsal stricturotomy is transversely closed.

Since the description of both techniques, some authors have compared classic EPA with new non-transecting modifications, presenting contradictory data. Haines *et al.* failed to find statistical differences between transecting and non-transecting groups regarding EF (22). Chapman *et al.* (21) retrospectively compared 94 non-transecting urethroplasties *vs.* 258 EPA, with a mean follow-up of 64.2 months. *De novo* SD appeared more frequently in EPA cohort than in the non-transecting cohort (14.3% *vs.* 4.3%, respectively; P=0.008). On multivariate analysis, urethral transection was the only factor associated with SD (P=0.01).

Lumen *et al.* (33) proposed a ventral stricturoplasty, following the Heineke-Mikulicz principle. The indication of this technique is restricted to short (≤1 cm), not too narrow strictures in bulbar urethra or fossa navicularis. They used a non-validated questionnaire to assess SF. None of 9 patients who were sexually active (6 with bulbar strictures) reported ejaculatory disturbances, ED, or diminished penile sensitivity.

Grafting techniques are usually indicated in longer bulbar strictures (>2–3 cm) and may benefit from maintaining the urethral vasculature intact.

Palminteri *et al.* (12) reported the impact of ventral BMG urethroplasty on sexual life of 52 patients, using MSHQ and their unvalidated Post-Urethroplasty Sexual Questionnaire (PUSQ), 1 year postoperatively. No patient complained of worsened erection, whereas 18 (35%) of them reported better erections. This improvement is probably related to an amelioration of quality of life. The same group (34) also described a two-sided bulbar urethroplasty using dorsal plus ventral BMG. They developed this technique for tight bulbar strictures. None of 49 sexually active men reported impaired erection compared to preoperative status. Moreover, EF improvement was reported by 7 patients (14%).

Spencer *et al.* (35) evaluated the consequences of dorsal

BMG onlay technique described by Kulkarni et al. for strictures longer than 8 cm. They found no significant difference in preoperative and postoperative SHIM score (19.7 vs. 18.1; P=0.17). Most patients demonstrated no change in IIEF5 score (67%) or even an improvement of ≥4 points (14.3%). However, 21.4% of patients reported a reduction of ≥4 points in SHIM score.

Several authors have evaluated whether grafting techniques are superior to transecting bulbar urethroplasty regarding SF outcomes.

Kessler et al. (36) evaluated 267 patients who underwent surgical repair of urethral strictures. As there were no validated questionnaires on urethral stricture at the time, they designed a non-validated questionnaire to assess voiding, sexual function, and satisfaction. The patients were assessed after a median 37 months from the surgery. In the EPA group, 79% of 39 patients reported moderate to severe erection impairment, whereas in BMG group only 15% of 29 patients demonstrated such deterioration. Of those treated with BMG, 81% reported none or little impairment in sexual life, while in 43% of EPA, sexual life was severely impaired.

Beysens et al. (37) compared AU (31 cases) with free graft urethroplasty (16 cases). They evidenced a significant decline in IIEF5 score after 6 weeks in AU group (–4.8; P=0.005) but not in a free graft cohort (+0.9; P=0.115). After 6 months, there were no longer significant changes in IIEF5 score in any of the groups.

Erickson et al. (24) reported that men undergoing EPA had higher postoperative ED rates than those submitted to augmented anastomotic repairs (AAR) (50% vs. 26%, P=0.16). This high postoperative ED rates are recognised early in postoperative period (mean 2 months) but are mostly transient, with only 2 men reporting persistent ED after a median follow-up of 6 months.

Dogra et al. (19) reported a postoperative ED rate of 28% for EPA, and 10% for BMG urethroplasties. However, recovery of EF was seen in 96% on men, and only 3 patients from EPA group continued to have ED at the end of this study (mean follow-up 5.6 months).

Furr et al. (38) reported sexual results of their cohort of bulbar urethroplasties using EPA (96 patients) vs. dorsal BMG urethroplasty (32 patients). There were no significant differences between groups regarding IIEF5 postoperative score (BMG 18.4 vs. EPA 17.1), patients with IIEF5 >15 (BMG 69% vs. EPA 69%), potency or difficulty achieving erections (BMG 31% vs. EPA 27%).

In summary, there is no consensus whether anastomotic

techniques affect ED more than grafting techniques. Results are largely variable, with ED reported rates between 0–79% in EPA and 0–26% in augmentation urethroplasties. Indeed, these studies are difficult to compare because of different assessment or different time moments. It seems that in most cases early postoperative ED may be transient: 6 studies reported resolution of ED between 6–20 months after surgery (17,19,23,24,30,37). Non-transecting techniques seem to diminish vascular damage secondary to EPA repairs, but their clinical benefit over EF is yet to be consistently proven (see Table 1 for details). There is an ongoing prospective, multi-center, randomized, non-inferiority trial, comparing transecting and non-transecting techniques (46). This study will provide evidence on both surgical and functional results after these techniques, including erectile function, and will try to shed light on the value of bulbar artery preservation.

Ejaculatory dysfunction after anterior urethroplasty

Changes in ejaculatory function after bulbar urethroplasty
EjD can be already present before urethroplasty. Urethral obstruction may cause impact on ejaculatory function itself. Preoperative reported prevalence is wide, ranging from 0 to 85%. According to Erickson et al. (47), 25% of patients reported poor preoperative ejaculatory function. The most common related problems were poor ejaculatory volume (100%), vigor (91%) and pain with ejaculation (100%). Palminteri et al. (12) also described preoperative ejaculatory disorders related to bulbar strictures in a prospective study of 52 men. The patients reported reduced ejaculatory stream (85%), painful ejaculations (27%), and ejaculation failures (27%). These and others sexual disorders had influenced quality of life in 46% of the patients.

Most studies reported improved ejaculatory function after restoration of urethral lumen. However, sometimes EjD persisted or even worsened. This may be explained by bulbospongiosus muscle (BSM) division during bulbar urethroplasty, or by perineal nerve damage. BSM is known to have an important role in semen emission and probably in urine expelling too, avoiding urine sequestration in the urethral bulb. The perineal nerve can be damaged during dissection of the central tendon of perineum, when it is emerging from ischiorectal fossa or, when BSM is fully divided along its midline, causing both sensitivity deficiencies and possibly ejaculatory disorders.

Barbagli et al. (29) retrospectively studied the sexual consequences of bulbar EPA with a non-validated telephone

Table 1 Summary of erectile function (EF) changes after urethroplasty

Author, year	Study type	N° patients	Stricture location	Procedure [n]	Follow-up, months	Preoperative EF	Questionnaires	Results on EF
Coursey et al., 2001, (16)	Prospective	174*	Anterior	AU [56]; BMG urethroplasty [26]; penile flap [44]; others [26]; circumcision [22]	36 [3–149]	No	Internally validated questionnaire (coursey questionnaire)	Postoperative EF: 69.1% improved /not changed, 30.9% worsened. No statistically significant difference among groups, including circumcision group
Kessler et al., 2002, (36)	Prospective	233/267**	Anterior	BMG [29]; pedicled flap [97]; AU [39]; mesh graft [68]	28.9	No	Non validated questionnaire [216] or telephone interview [17]	Overall erection deterioration: moderate 14.2%, severe 25.8%; moderate to severe deterioration was reported in 30% and 49% of AU patients vs. 4% and 11% of BMG patients
Raber et al., 2005, (39)	Prospective	30	Bulbar	Penile skin graft [17]; BMG [13]	51 [20–74]	Yes	IIEF15	Erectile function domain did not change significantly after 18 months of follow-up: BMG, preop IIEF-ED 24 vs. postop 24.8, P=0.77; penile skin: preop IIEF-ED 24.78 vs. postop 25.67, P=0.79
Erickson et al., 2007, (17)	Retrospective	52	Anterior	AU [23]; BMG onlay [22]; BMG 2-stage [7]	22.3 [SD 14.8]	Yes	BMFSI	No significant differences in the mean EF scores before and after surgery. 25% reported lower EF scores after surgery. Improvement in EF score after 1 year. Neither technique nor length of stricture significantly altered overall EF
Morey et al., 2006, (28)	Retrospective	22	Bulbar: (I) stricture ≤2.5 cm; (II) stricture >2.5 cm	Group 1: AU [11]; Group 2: extended anastomotic urethroplasty (EAU) [11]	26.1 [16–64]	Not reported	Coursey questionnaire	EF similar between groups; moderately/very satisfactory erections: 55.6% AU vs. 83.3% EAU; complete loss of erection: 18% AU vs. 0% EAU
Anger et al., 2007, (18)	Prospective	25	Bulbar	AU [8]; AAR [10]; complex AU [5]; dorsal onlay [2]	6.2	Yes	IIEF15	De novo ED 1/25. 7/25 had pre-existing ED; men with a postoperative score of ≤20 were older and had worse preoperative EF
Barbagli et al., 2007, (29)	Retrospective	60/153	Bulbar	AU	68	Not reported	Non-validated	0% de novo ED
Xie et al., 2009, (23)	Prospective	125	Anterior [41]; posterior [54]	Dorsal patch [55]; Bulboprostatic AU [70]	27.3 [6–60]	Yes	IIEF5, QoLQ, SLQQ	39.2% (49) preoperative ED. 5/49 patients became potent after surgery. 69.6% postoperative ED. Stricture recurrence, location and procedure showed a strong association to ED
Erickson et al., 2010, (24)	Prospective	52	Bulbar [35]; penile [17]	AU [20]; AAR [15]; ventral onlay [11]; staged repair [5]	217 [17–685]	Yes	IIEF5	44% preoperative ED. 38% postoperative ED. Of men with normal preoperative EF, 66% postoperative ED (bulbar 76% vs. penile 38%; P=0.05). 18/20 reported back to normal EF (90%), after a mean 190 days

Table 1 (continued)

Table 1 (*continued*)

Author, year	Study type	N° patients	Stricture location	Procedure [n]	Follow-up, months	Preoperative EF	Questionnaires	Results on EF
Lumen et al., 2010, (40)	Prospective	9/10 sexually active	Bulbar [6]; fossa navicularis [4]	Heineke Mikulicz stricturoplasty	46.6 [15–79]	Not stated	Non-validated	0% ED
Dogra et al., 2011, (19)	Prospective	78	(I) Penile; (II) bulbar <4 cm; (III) bulbar >4 cm	(I) Penile: ventral penile flap [14], dorsal inlay graft [11]; (II) AU [32]; (III) dorsal BMG [21]	15.50 [12–21]	Yes	IIEF5	20% postoperative ED: 16% penile, 28% AU, 10% BMG; 96% recover EF at a mean follow-up of 5.63 months
Johnson et al., 2011, (41)	Retrospective 37/183**		Anterior	AU; staged-urethroplasty; BMG urethroplasty; hypospadias repair; other	9	Yes	IIEF5	65% no change, 8% improvement, 27% clinically significant decline in EF. No difference in IIEF5 score change by age (<55 vs. ≥55 years)
Palminteri et al., 2011, (12)	Retrospective 49/73*		Bulbar	Two sided bulbar urethroplasty with BMG	12	No	Coursey questionnaire	0% postoperative ED, 14% erectile improvement
Lumen et al., 2011, (33)	Prospective	20	Anterior	Not reported	6	Yes	IIEF5	Mean IIEF-5 score: 15 preoperative vs. 12.13 at 6 weeks vs. 11.62 at 6 months postoperative
Palminteri et al., 2013, (12)	Prospective	52	Bulbar	Ventral BMG bulbar urethroplasty	12	Yes, MSHQ	MSHQ, PUSQ	After urethroplasty, 0% worsened erection, whereas 35% reported an improved erection
Delong et al., 2013, (20)	Prospective	100	Anterior	BMG [60]; AU [32]; fasciocutaneous flap [11]; staged urethroplasty [7]	12 [10–13]	Yes	IIEF	Median IIEF change postoperatively 0 (IQR −1 to 2); 5% report significant postoperative decrease in IIEF, 14% significant increase; no difference was found by age or procedure type
Pfalzgraf et al.., 2014, (25)	Retrospective 33		Bulbar [17]; penile [16]	Re-do urethroplasties	11.8	No	IIEF15	IIEF-EF median score 26.5/30 (IQR, 8.25–27.25) (penile group) vs. 14 (IQR, 2–26) (bulbar group) (P=0.47)
Levine et al., 2014, (42)	Retrospective 476		Anterior	Re-do urethroplasty [49]; naïve [427]	50	No	Non-validated	5% worsened EF. No difference between both groups; postoperative ED occurred with all stricture aetiologies, locations, and types of surgery
Patel et al., 2015, (27)	Retrospective 25/33**		Penile	BMG staged repair	6.3 [IQR: 3.5–13.3] after 2nd stage	Yes, IIEF5	IIEF5 + Coursey questionnaire	Median postoperative IIEF5 score 23 (IQR: 19–25); IIEF5 mean difference −0.64 (SD: 5.72); 1 patient required ED medication

Table 1 (*continued*)

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Author, year	Study type	N° patients	Stricture location	Procedure [n]	Follow-up, months	Preoperative EF	Questionnaires	Results on EF
Palminteri et al., 2015, (43)	Retrospective	12*	Bulbar	Two-sided bulbar urethroplasty with BMG and preputial skin	12	No	Coursey questionnaire	0% de novo ED. 25% patients had erectile improvement
Beysens et al., 2015, (37)	Prospective	33/47*	Bulbar	AU [31]; free graft urethroplasty [16]	23.3 [SD 10.9]	Yes	IIEF5	There was a significant decline in IIEF-5 score after 6 weeks, but not at 6 months
Maciejewski et al., 2016, (44)	Prospective	94	Penile [21]; bulbar [74]; posterior [4]; panurethral [3]	AU [24]; penile island flap [4]; BMG [66]; staged [8]	6		Institution-based QoLQ + IIEF5	13% de novo ED; mean EF score: 17.9 (±12) preoperatively vs. 16.3 (±11) postoperatively (P>0.05)
Spencer et al., 2017, (35)	Retrospective 42 /73		Panurethral	One-sided urethral dissection, penile invagination, and dorsal BMG onlay	44 [12–162]	Yes	IIEF5	IIEF5 score: 67% no change; 19% ≥4 points score reduction; 14% ≥4 points increase
Haines et al., 2017, (22)	Prospective	87	Penile [23]; bulbar [64]	BMG onlay [49]; staged [15]; AU [23] (transecting and non-transecting)	6	Yes	IIEF	No significant change in EF postoperatively (20.16 vs. 20.14); 20.7 % had ≥5 points decrease in EF score; 17.2% significant improvement. No difference associated to stricture location or transection
Onol et al., 2017, (45)	Prospective	34/42*	Penile [9]; bulbar [23]; panurethral [6]; multiple [4]	AU [4]; BMG [38]	6	Yes	IIEF5	No significant differences in mean IIEF-5 score pre and postoperatively (16 vs. 14, P=0.07)
Shakir et al., 2018, (26)	Retrospective	14	Penile	AU	43 [IQR, 26–121]	Yes	IIEF5	0% de novo ED; median postoperative IIEF5 score 21 [19–25]
Furr et al., 2019, (38)	Retrospective	179	Bulbar	Transecting AU [96]; dorsal buccal graft [DBG] [32]	DBG 51.4; AU 63.3	No	IIEF5	No difference in IIEF5 score between groups; EF deterioration after surgery: DBG 31% vs. AU 27%
Chapman et al., 2019, (21)	Retrospective	352	bulbar	Non transecting 94; AU 258	AU 64.2 [6–170]	Yes	IIEF5	Overall, 9.7% de novo ED; 14.3% AU vs. 4.3% non-transecting cohort. Urethral transection was associated with sexual dysfunction (P=0.01)
D'Hulst et al., 2019, (30)	Prospective	23/47*	bulbar	AU	1st, 2.2; 2nd: 8.5; 3rd: 20.2	Yes	IIEF5	Patients with mild/no baseline ED [15] had a significant decline in EF at the 1st follow-up which was fully recovered by 3rd follow-up (IIEF-5: 23.25). Patients with moderate/severe ED at baseline (8) experienced no significant change in EF

*, sexually active; **, completed the questionnaires. ED, erectile dysfunction; EF, erectile function; AU, anastomotic urethroplasty; BMG, buccal mucosa graft; IIEF, International Index of Erectile Function; AAR, augmented anastomotic repairs; QoLQ, Quality of Life Questionnaire; SLQQ, Sexual Life Quality Questionnaire.

questionnaire. 20% of patients experienced decreased ejaculation force and 3.3% of the patients reported semen sequestration in urethral bulb. According to the hypothesis that EjD is secondary to BSM division or perineal nerve damage, they developed a BSM-sparing bulbar urethroplasty technique (48). They report a series of 12 patients with bulbar urethroplasty preserving bulbospongiosus muscle, central tendon of perineum, and perineal nerves. No patient showed decreased force of semen emission nor postvoiding dribbling at 6 and 12 months after surgery.

Later, Fredrick et al. (49) designed a comparative study to evaluate the effects of BSM sparing during bulbar urethroplasty. Patients were assessed pre- and postoperatively with MSHQ as well as a patient perception questionnaire. They found no significant differences between BSM sparing and non-sparing groups in mean post-operative MSHQ score or MSHQ score change. Their findings failed to demonstrate any short-term differences in post-operative ejaculatory function by preserving BSM. When broken down by EPA vs. graft, there was no significant difference in perception of ejaculation between BSM-sparing and non-sparing groups.

Ejaculation dysfunction could also be related to out-pouching and diverticulum formation after ventral substitution techniques. Dubey et al. (50) presented a series of urethral strictures repaired either with skin flap or free graft. Patients with ventral flap/graft onlay urethroplasty reported a higher incidence of EjD (20%), in the form of scanty ejaculation, compared to dorsal onlay (5%; P=0.03). They corroborated the presence of flap out-pouching during follow-up in 26% of ventral onlay urethroplasties vs. 3% of dorsal onlay (P=0.01).

This data contrasts those of Palminteri et al. (12). They evaluated ejaculatory function with both MSHQ-LF and PUSQ questionnaires in their series of ventral BMG bulbar urethroplasty. After surgery, most of their patients had an improved ejaculation (65%) in terms of force, volume, and pleasure. They showed post-urethroplasty improvement both in total MSHQ score and in each of the principal domains, including ejaculation score, ejaculation bother score, sexual activity, and desire score. Only 19% of the patients reported worsened ejaculation because of post-ejaculation dribbling or reduced stream.

Even in longer strictures, ejaculatory function seems to improve in most cases after urethroplasty. Spencer et al. (35) analysed this aspect in 25 patients with strictures >8 cm treated by dorsal BMG onlay technique, using both pre- and post-operative MSHQ-EjD questionnaires. MSHQ-EjS

scores had improved from 8 (range, 4–13) preoperatively to 11 (range, 4–15) postoperatively (P=0.0004). Seventy-six percent of the patients reported improved ejaculation, 16% reported worsened ejaculation, and 8% had no change.

Erickson et al. (47) designed a prospective study evaluating EjD in 43 sexually active patients through MSHQ-EjS questionnaire prior and after urethroplasty. They reported stable ejaculatory function in 70% of the men, increased in 19%, and decreased in only 11%. No significant changes were found in overall ejaculatory scores at a median follow-up of 6.8 months. On subanalysis, men with poor preoperative ejaculatory function had a significantly improved score postoperatively. Likewise, significant amelioration was seen in most MSHQ ejaculatory categories. Mean stricture length in patients reporting decreased ejaculatory function was 4.1±1.1 cm, not significantly different from men with stable or improved ejaculation (P=0.81). No patient with normal ejaculatory function preoperatively had significantly decreased function after urethroplasty nor had recurrent strictures during the study period.

Again, AU and augmentation techniques have been largely compared, but they do not seem to differ regarding postoperative ejaculatory function. Beysens et al. (37) prospectively compared AU or grafting for bulbar strictures. EPA was preferred whenever a tension-free anastomosis could be made (stricture length <3 cm); for longer strictures, augmentation was performed. Thirty-seven patients filled the Ejaculatory/Orgasm Score (EOS) questionnaire prior and after surgery (23 EPA vs. 14 graft augmentation). EOS is calculated from the sum of questions 9 and 10 from IIEF, and it ranges from 2 (no ejaculation/orgasm) to 10 (normal). Although overall there was no significant postoperative change in EOS; patients in EPA group had a transient significant decline in EOS score at 6 weeks (–1.4; P=0.022) which returned to baseline at 6 months (–0.4; P=0.431).

Furr et al. (38) compared EPA -selected for shorter (<3 cm), more proximal bulbar strictures—with dorsal BMG urethroplasty—typically reserved for longer strictures (>3–3.5 cm) or those located in distal bulbar urethra. They found no differences between groups in terms of postoperative MSHQ-EJD ejaculatory score or bother.

Changes in ejaculatory function after penile urethroplasty

The TURNS Group (27) reviewed ejaculation after staged penile urethroplasty in 57 patients. Only 20 patients filled in preoperative and postoperative MSHQ-EjD questionnaires.

There was no statistically significant difference in scores before and after penile urethroplasty. Mean difference in pre- and postoperative MSHQ score was 1.55 (SD =6.57). For question 4 on the MSHQ-EjD, 40% reported reduced EjD bother, and 45% reported no change. This data may be biased by the reduced questionnaire completion rate (35%).

Changes in ejaculatory function after revision urethroplasty

Ejaculation function after re-do urethroplasties was assessed by Pfalzgraf *et al.* (25). When asked about ejaculation after surgery, 63.6% of patients reported normal ejaculatory function, while 15.2% and 3% reported a slight or a severe decrease in ejaculation strength, respectively. No differences between bulbar and penile strictures were found in this aspect.

In summary, patients may already present EjD secondary to urethral lumen obstruction previous to urethroplasty. Urethral repairs improve ejaculatory function in most cases, but it may worsen in 0–20% of the patients (see *Table 2* for details). According to Palminteri *et al.* (12), some manoeuvres can be implemented to reduce the risk of ejaculatory disorders:

❖ Careful midline opening of bulbospongiosus muscle;
❖ Avoiding damaging of the nerve branches positioned more laterally;
❖ No division of perineal central tendon that takes part in the ejaculatory mechanism;
❖ Good coverage of the graft with corpus spongiosum;
❖ Reconstructing the bulbospongiosus muscle.

Penile shortening and curvature

Penile length loss and penile curvature are potential complications after urethral reconstruction, and depending on their degree, they can severely impair sexual life and be a cause of patient's dissatisfaction with urethroplasty outcomes (36).

Penile shortening and curvature after urethroplasty in the bulbar urethra

Coursey *et al.* (16) assessed the change in penile angulation and shortening through a non-validated questionnaire after anterior urethroplasty. Most patients reported no change in penile angulation. Those patients who noticed an altered erectile angle or penile length had a significantly longer

Table 2 Summary of ejaculatory changes after urethroplasty

Author, year	Type of study	N° patients	Stricture location	Procedure [n]	Follow-up [months]	Preoperative Questionnaire	Questionnaire	Ejaculatory function results
Dubey *et al.*, 2003, (51)	Retrospective	109	Pendulous [14]; pendulobulbar [39]; bulbar [56]	Ventral flap [52]; dorsal flap [23]; ventral graft [18]; dorsal graft [16]	37.8 [19], 22.4 [11], 45.7 [13], 22 [10.3]		Not stated	Ventral flap/graft onlay had a higher incidence of ejaculatory dysfunction (20%) compared to dorsal (5%) repair
Erickson *et al.*, 2006, (17)	Retrospective	52	Anterior	AU [23]; BMG onlay [22]; Staged BMG [7]	22.3 [14.8]	Yes	BMSFI	Significant increase in overall EjF score after surgery (preop 5.3 vs. postop 6.2)
Barbagli *et al.*, 2007, (29)	Retrospective	60	Bulbar	AU	68	No	Non-validated	20% experienced decreased ejaculation force and 3.3% semen sequestration
Barbagli *et al.*, 2008, (48)	Prospective	12	Bulbar	Ventral onlay BMG [6]; dorsal onlay BMG [6]	15.25 [12–26]	No	Non-validated	Bulbospongiosum muscle and central tendon of the perineum were left intact; no patient showed decreased force of semen emission or postvoiding dribbling after surgery
Erickson *et al.*, 2010, (47)	Prospective	43	Penile [13]; bulbar [30]	Bulbar: AU [17], AAR [11]; penile: ventral BMG onlay [11], staged [2]	6.8±5.2	Yes	MSHQ-EjS	25% reported poor preoperative EjF. After surgery, EjF was stable in 70%, increased in 19%, and decreased in 11% of the patients

Table 2 (*continued*)

Table 2 (*continued*)

Author, year	Type of study	N° patients	Stricture location	Procedure [n]	Follow-up [months]	Preoperative	Questionnaire	Ejaculatory function results
Palminteri et al., 2011, (34)	Retrospective	49*	Bulbar	Two-sided bulbar urethroplasty with BMG	12	No	Coursey Questionnaire	12% reported ejaculatory improvement and 4% decreased ejaculatory flow
Sharma et al., 2011, (52)	Prospective	34	Pendulous [7]; bulbar [18]; bulbomembranous [2]; panurethral [7]	AU [18]; dorsal BMG onlay [9]; BMG staged repair [7]	8.4 [3–13]	Yes	BMSFI	Patients <40 years had significant improvement in EjF after surgery. In patients >40 years, only marginal benefit was seen
Palminteri et al., 2013, (12)	Prospective	52	Bulbar	Ventral BMG bulbar urethroplasty	12	Yes	MSHQ; PUSQ	Preoperatively: 85% reported reduced ejaculatory stream, 27% painful ejaculations, and 27% had ejaculation failures; after urethroplasty, 65% improved ejaculation, 19% worsened ejaculation
Pfalzgraf et al., 2014, (25)	Retrospective	33	Bulbar [17]; penile [16]	Re-do urethroplasties:	11.8 [5–22]	No	IIEF15	Ejaculation strength was normal in 63.6 %, slightly reduced in 15.2% or severely reduced in 3%. No differences for location
Patel et al., 2015, (27)	Retrospective	20/33**	Penile	Staged BMG repair	6.3	Yes	MSHQ-EJS	Mean postoperative MSHQ-EjD score 16.5 (SD: 4.2); no statistically significant difference in scores before and after penile urethroplasty; 40% reported reduced ejaculatory dysfunction bother, and 45% no change
Beysens et al., 2015, (37)	Prospective	37/47*	Bulbar	Free graft urethroplasty [14]; AU [23]	23.3 [10.9]	No	EOS score: Q9/Q10 of IIEF15. Range 2 (no ejaculation) to 10 (normal)	Overall, no significant postoperative change in EOS at 6 weeks; in AR group there was a significant decline in EOS at 6 weeks, but it was no longer significant after 6 months; FGU group did not experiment a decline
Fredrick et al., 2016, (49)	Retrospective	50	Bulbar	Muscle sparing [BS] [25]; non muscle sparing [non-BS] [25]	7.4 [2.6–24.8]	Yes	MSHQ-EJS and non-validated questionnaire	No statistically significantly differences in mean post-operative MSHQ score between groups (15.24 BS vs. 15.4 non-BS)
Spencer et al., 2017, (35)	Retrospective	25/73	Panurethral	One-sided anterior urethroplasty [Kulkarni technique]	44 [12–162]	Yes (recall)	MSHQ-EJS	MSHQ-EjS score significantly improved after surgery [8 (4–13) vs. 11 (4–15); P<0.0004]; 19 patients reported improved ejaculation, 4 worsened, and 2 no change
Furr et al., 2019, (38)	Retrospective	179	Bulbar	Dorsal BMG [32]AU [96]	DBG 51.4; AU 63.3	No	MSHQ-EJS	No differences between groups in ejaculatory score (9.4 DBG vs. 10.5 AU) or ejaculatory bother (1.59 DBG vs. 1.07 AU)

*, sexually active; **, completed the questionnaire. AU, anastomotic urethroplasty; BMG, buccal mucosa graft; IIEF, International Index of Erectile Function; MSHQ-EjS, Male Sexual Health Questionnaire; EOS, Ejaculatory/Orgasm Score; BMSFI, O'Leary Brief Male Sexual Function Inventory.

stricture than those who did not (P=0.05). A "major change" in erect angle was reported in 8.9% AU and 7.7% BMG urethroplasties. However, most patients reported that it improved over time.

Kessler *et al*. (36) assessed a series of 225 patients after different anterior urethroplasties. In this study, patients reported none/little, moderate or severe curvature in 74.7%, 15.1% and 10.2% respectively.

EPA was associated with a higher proportion of severe penile shortening (30%) compared with the overall severe shortening (15.6%). The EPA group suffered moderate or severe curvature in 22% and 14% of cases respectively, while BMG urethroplasty group declared a 4% moderate and 4% severe postoperative penile curvature. None of BMG urethroplasty patients reported severe shortening. Although AU is a successful treatment, the increased risk of penile shortening and chordee has led to the thought of reserving this procedure for short bulbar strictures (<3 cm). Following this principle, Barbagli *et al*. (29) used EPA in 153 patients of which 91 (59.5%) had strictures <2 cm and 58 (37.9%) strictures ranging from 2 to 3 cm, using this technique in only 4 patients (2.6%) with strictures longer than 3 cm. No patient complained of penile chordee or ED.

Morey *et al*. (28) compared anastomotic repair in strictures shorter (group 1) or longer than 2.5 cm (group 2). Surprisingly, 44.4% of patients in group 1 reported some penile angulation and 22% a mild decrease of penile length, while 0% and 33% of the patients in group 2 reported penile angulation or mild shortening, respectively.

Regarding the use of substitution techniques, Palminteri *et al*. (12) reported that 8% of the patients developed "a little" curvature after ventral BMG urethroplasty, and 4% "a little" shortening, with no patient reporting severe changes. In their series of 2-sided bulbar urethroplasty with BMG (34), none of the patients reported penile length loss or postoperative curvature.

Furr *et al*. (38) compares the results of EPA versus dorsal BMG urethroplasty in a series of 179 patients. Tethering with erections was significantly more frequent with EPA (23.4%) *vs.* BMG (3.1%). However, 76% of patients who experienced tethering reported completely satisfactory sexual activity.

Penile shortening and curvature after urethroplasty for penobulbar strictures

Long panurethral strictures repair may imply higher risk of penile shortening and chordee. Kulkarni *et al*. (53) developed a technique including 1-sided urethral dissection,

penile invagination and dorsal BMG onlay, that attempts to minimize over-mobilization or excision of the urethra. It is mandatory to keep the penis stretched during the procedure to allow loose graft fixation. Spencer *et al*. (35) report their sexual outcomes using this technique in a cohort with a mean stricture length of 13.6 cm (8–21 cm). They found 25% of patients with chordee. Curvature was transient and resolved by the first year in 13/18 men (72%); however, 2 patients required surgical correction using a dorsal plication technique.

Penile shortening and curvature after urethroplasty in the penile urethra

Anastomotic repair is normally avoided in penile stricture. However, Shakir *et al*. (26) presented a series of 14 focal penile strictures—median length 1.0 cm (IQR. 1.0–1.4)—repaired with EPA. No patients reported *de novo* penile curvature or penile shortening postoperatively.

Regarding different techniques in penile strictures, Coursey *et al*. (16) assessed penile flap urethroplasty resulted in slightly more penile shortening and erectile angle alteration (18.9%) than other procedures (P=0.05).

The TURNS group (27) evaluated staged penile urethroplasties using BMG. They report new penile curvature in 23% of the patients. Also, when questioned, 10% patients complained of "quite a bit a loss" in penile length while 45% stated "somewhat of a loss".

Penile shortening and curvature after revision urethroplasty

Two studies specifically address re-do urethroplasties. Levine *et al*. (54) found that the incidence of chordee was higher in the re-do group (14.3%) compared to primary urethroplasties (2.7%). Pfalzgraf *et al*. (25) found an overall penile curvature of 15.2%. No patient reported a strong deviation, but all patients complaining of moderate chordee (18.8%) underwent previous penile urethroplasties. Describing length loss, any penile shortening was reported by 17.6% of bulbar urethroplasty patients compared with 37.6% of those operated in the penile urethra. Severe length loss was a consequence of 5.9% and 6.3% of bulbar and penile urethroplasties, respectively.

A common limitation to all the studies is the subjective nature of the reports. None of the retrieved literature included objective measurement of the degree of curvature or penile length loss, neither the authors described how severity was categorized. This heterogeneity makes it exceedingly difficult to compare reported outcomes.

Table 3 Summary of penile length loss after urethroplasty

Author, year	Study type	Nº patients	Stricture location	Procedure	Follow-up (months)	Results
Coursey et al., 2001, (16)	Prospective	174*	Anterior	AU [56]; BMG urethroplasty [26]; penile flap [44]; others [26]; circumcision [22]	36 [3–149]	Major change in erect length: 27.3% penile flap; 10.7% AU; 15.4% BMG; 11.5% others; 22.7% circumcision; patients with change in penile length had a significantly longer stricture (P=0.05)
Kessler et al., 2002, (36)	Prospective	233/267**	Anterior	BMG [29]; pedicled flap [97]; AU [39]; mesh graft [68]	28.9 [12–73]	Overall: 15,6% severe penile shortening; marked or severe penile shortening: 0% BMG, 11% flap, 30% AU, 21% mesh graft
AL Qudah et al., 2005, (55)	Retrospective	60	Prostatomembranous [1]; membranobulbar [8]; bulbar [41]; penile [12]	AU [24]; ventral onlay BMG [19]; onlay flap [10]; posterior AU [9]	29 [10–53]	1 patient who underwent onlay flap reported shortening
Morey et al., 2006, (28)	Retrospective	22	Bulbar: group 1 [11], stricture ≤2.5 cm; group 2 [11]: stricture >2.5 cm	Group 1: AU; Group 2: extended anastomotic urethroplasty	26.1 [16– 64]	Mild, persistent shortening 33.3% group 2 vs. 22.2% in group 1 (P=0.4), 0% severe shortening
Palminteri et al., 2011, (34)	Retrospective	49/73*	Bulbar	Two sided bulbar urethroplasty with BMG	12	0% penile shortening
Palminteri et al., 2013, (12)	Prospective	52	Bulbar	Ventral BMG bulbar urethroplasty	12	4 % a little shortening; 0% marked shortening
Pfalzgraf et al., 2014, (25)	Retrospective	33	Bulbar [17]; penile [16]	Re-do urethroplasties	11.8	Overall: 9.1% reported moderate shortening and 6.1% severe length loss: Bulbar: moderate 11.8%, severe 5.9%; penile: moderate 6.3%, severe 6.3%
Patel et al., 2015, (27)	Retrospective	22/33**	Penile	BMG staged repair	–	10% "quite a bit a loss" in penile length; 45% "somewhat of a loss"
Palminteri et al., 2015, (43)	Retrospective	12*	Bulbar	Two sided bulbar urethroplasty with BMG and preputial skin	12	0% penile shortening
Shakir et al., 2018, (26)	Retrospective	14	Penile	AU	43 [IQR, 26–121]	0% penile shortening

*, sexually active; **, completed the questionnaires. AU, anastomotic urethroplasty; BMG, buccal mucosa graft.

Anastomotic techniques are thought to have an increased risk of penile curvature and shortening compared to other techniques. Such risk increases with stricture length and penile involvement, and also when revision surgeries are required. However, the available data are scarce, and further and objective investigations are needed in the topic (see *Tables 3,4* for details).

Cold glans sensation and decreased penile sensitivity

Patients may refer incomplete glans tumescence and genital area sensitivity changes after urethroplasty. These undesirable consequences could interfere with sexual satisfaction. Cold glans is traditionally attributed to the transection of corpus spongiosum for primary anastomosis,

Table 4 Summary of penile curvature after urethroplasty

Author, year	Study type	Nº patients	Stricture location	Procedure [n]	Follow-up (months)	Results
Coursey et al., 2001, (16)	Prospective	174*	Anterior	AU [56]; BMG urethroplasty [26]; penile flap [44]; others [26]; circumcision [22]	36 (range, 3–149)	Major change in erect angle: 8.9% AU; 7.7% BMG; 18.2% penile flap; 23.1% other; 9.5% circumcision
Kessler et al., 2002, (36)	Prospective	233/267**	Anterior	BMG [29]; pedicled flap [97]; AU [39]; mesh graft [68]	28.9 [12–73]	Severe chordee: overall 10.2%; by procedure, 4% BMG, 5 % flap, 14 % AU, 18 % mesh graft
AL Qudah et al., 2005, (55)	Retrospective	60	Prostatomembranous [1]; membrano-bulbar [8]; bulbar [41]; penile [12]	AU [24]; ventral onlay BMG [19]; onlay flap [10]; posterior AU [9]	29 [10–53]	Chordee was reported in 4% AU; 0% BMG; 20% onlay flap; 11% posterior
Morey et al., 2006, (28)	Retrospective	22	Bulbar: group 1 [11], ≤2.5 cm; group 2 [11]: >2.5 cm	Group 1: AU; Group 2: extended AU	26.1 [16–64]	44.4% in group 1 noticed some angulation, 0% in group 2
Barbagli et al., 2007, (29)	Retrospective	60/153	Bulbar	AU		0 % reported curvature
Palminteri et al., 2011, (34)	Retrospective	49/73*	Bulbar	Two sided bulbar urethroplasty with BMG	12	0% postoperative penile curvature
Palminteri et al., 2013, (12)	Prospective	52	Bulbar	Ventral BMG bulbar urethroplasty	12	8% "a little" curvature, 0% marked curvature
Pfalzgraf et al., 2014, (25)	Retrospective	33	Bulbar [17]; penile [16]	Re-do urethroplasties	11.8	Penile curvature was more frequently reported after penile urethroplasty (25.1% vs. 5.9% in bulbar urethroplasty)
Levine et al., 2014, (42)	Retrospective	476	Anterior	Re-do 49; naïve 427	50	Chordee in 2.7% naïve vs. 14.3% re-do; P<0.01
Patel et al., 2015, (27)	Retrospective	22/33**	Penile	BMG staged repair		23% reported postoperative penile curvature
Palminteri et al., 2015, (43)	Retrospective	12*	Bulbar	Two sided bulbar urethroplasty with BMG and preputial skin	12	0% reported postoperative penile curvature
Maciejewski et al., 2016, (44)	Prospective	94	Penile [21]; bulbar [74]; posterior [4]; panurethral [3]	AU [24]; penile island flap [4]; BMG [66]; staged [8]	6	30% reported chordee. Only penile shortening (OR 2.26) and chordee (OR 2.26) retained statistical significance as independent predictors of patient satisfaction following urethroplasty
Spencer et al., 2017, (35)	Retrospective	42/73	Panurethral	1-sided urethral dissection, penile invagination, dorsal BMG onlay [Kulkarni technique]	44 [12–162]	25% chordee. This was transient and resolved by the first year in 72% of the patients; however, 2 patients required surgical correction
Shakir et al., 2018, (26)	Retrospective	14	Penile	AU	43 (IQR, 26–121)	0% postoperative curvature
Furr et al., 2019, (38)	Retrospective	179	Bulbar	Transecting AU [96]; dorsal BMG [DBG] [32]	DBG 51.4; AU 63.3	Chordee reported in 23.4% AU vs. 3.1% DBG (P=0.008). 76% of patients who experienced tethering reported completely satisfactory sexual activity

*, sexually active; **, completed the questionnaires. AU, anastomotic urethroplasty; BMG, buccal mucosa graft; DBG, dorsal buccal grafting.

which may lead to poor distal blood flow and consequently, impaired glans tumescence. Genital sensitivity disorders could be triggered by injuries to perineal nerve branches during bulbar urethral dissection.

In a cohort of patients evaluated after EPA for bulbar stricture, Barbagli *et al.* (29) reported 1.6% of them complaining of cold glans during erection, and 11.6% of poor glans tumescence. Also 18.3% described decreased sensitivity of the glans or distal penile shaft. However only the patient with cold glans reported dissatisfaction with the outcomes of surgery for this reason (1.6%).

After ventral BMG bulbar urethroplasty, Palminteri *et al.* (12) reported 42% of patients describing changes in sensitivity in scrotum or perineum, and 4% complaining of cold glans (all of them had a completely engorged glans). Conversely, none of the patients presented problems in their sexual activity because of these sensitivity disorders.

Beysens *et al.* (37) compared the results of anastomotic repair versus grafting urethroplasty—using prepuce (12 patients) and BMG (4 patients). They evaluated patients at 6 weeks and 6 months postoperatively, using a non-validated questionnaire containing 3 dichotomous questions about glans tumescence, alterations in genital sensitivity, and cold feeling in the glans. Further analysis of glans tumescence was only done in patients reporting normal EF (IIEF5 ≥20) in order to avoid contamination due to globally diminished penile tumescence. At 6 weeks, 62.2% reported to have altered genital sensitivity, without significant differences between groups. At 6 months, 52% still reported altered genital sensitivity. Only one patient, treated by AU, had a cold feeling in the glans, who no longer reported this feeling at 6 months. Of 20 patients with IIEF5 ≥20 at 6 weeks, 10% AU and 40% augmentation patients reported no glans tumescence (P=0.303). At 6 months, 16.7% (1 of 6 patients) AU and 60% (3 out of 5) augmentation patients, reported no glans tumescence (P=0.242). Although changes in genital sensitivity were not significantly different among subgroups, it is remarkable that augmentation urethroplasty patients reported a higher rate of sensitivity changes at 6 weeks (66.7% *vs.* 53.3% in AU group). The authors attribute these early changes to the use of preputial skin graft in most of these patients. However, even after 6 months, changes in genital sensitivity were still frequently reported, and this also occurred in patients treated with BMG.

In another comparison of EPA *vs.* dorsal graft urethroplasty, Furr *et al.* (38) reported decreased glans filling in 10.6% and 9.4% of patients, respectively. They also found decreased penile sensation in 23.4% and 18.8%

of EPA and grafting cohorts. Only 5.2% of EPA patients complained of cold glans, with none in the augmentation group (P=0.19). However, despite of cold glans, 4 of 5 patients reported satisfactory sexual intercourse.

After re-do urethroplasties in penile (16 cases) and bulbar (17 cases) areas, Pfalzgraf *et al.* (25) described non-disturbing alteration in glans sensitivity in 24.2% of the patients. In addition, 9.1% reported this alteration as disturbing. Glans sensitivity was more frequently impaired after penile urethroplasty (P=0.03). These authors hypothesize that the found difference is probably due to more extensive urethral mobilization in penile urethroplasty.

In summary, cold glans is described by 0–5% of patients after urethroplasty. Decreased glans tumescence is highly variable, ranging from 0% to 60% in grafting series and between 10% to 16% in anastomotic series. Genital altered sensitivity is reported in 10% to 50% of patients. However, what is really important is how these alterations affect patient's sexual life and satisfaction with their urethroplasty, as some of studies (12,29,38) stated that patients maintained a satisfactory sexual life regardless of presenting such disorders (see *Table 5* for details).

Relevance of sexual health complications in satisfaction after anterior urethroplasty

Some authors have addressed specifically how postoperative sexual changes affect patient satisfaction after urethroplasty.

Bertrand *et al.* (56) examined patient reported satisfaction following anterior urethroplasty. Men reporting satisfactory outcomes had higher postoperative SHIM scores (19.2 *vs.* 16.1, P<0.01), less change in postoperative SHIM scores (–0.04 *vs.* –3.2, P<0.01), higher postoperative MSQH-EJD scores (15.0 *vs.* 11.0, P<0.01) and greater postoperative ejaculation improvement (2.4 *vs.* 0.5, P=0.09) than patients reported as dissatisfied. Conversely, dissatisfied men were more likely to complain about alterations in sexual frequency (52% *vs.* 24%, P<0.01), new penile curvature (35% *vs.* 17%, P<0.02), alterations in penile length (48% *vs.* 32%, P<0.02), decreased penile sensitivity (36% *vs.* 20%, P<0.02) and cold glans during erection (12% *vs.* 3%, P<0.01) compared to men who rated themselves as satisfied. Persistent urinary symptoms, genitourinary pain and alterations in postoperative sexual function had the greatest effect on postoperative dissatisfaction. Notably, men reporting dissatisfaction had fourfold greater odds of experiencing a decrease in sexual activity (OR 4.36).

In a prospective series of 94 urethroplasty patients,

Table 5 Summary of genital sensitivity disorders and glans tumescence after urethroplasty

Author, year	Study type	N	Stricture location	Intervention	Follow-up (months)	Results
Barbagli *et al*., 2007, (29)	Retrospective	60/153**	Bulbar	Anastomotic urethroplasty	68	1.6% cold glans; 11.6% decreased glans tumescence; 18.3% decreased sensitivity of the glans or distal penile shaft
Palminteri *et al*., 2011, (34)	Retrospective	49 /73*	Bulbar	2-sided bulbar urethroplasty with BMG	12	2 % decreased glans sensitivity
Palminteri *et al*., 2013, (12)	Prospective	52	Bulbar	Ventral BMG bulbar urethroplasty	12	100% had a completely swollen glans; 4% reported cold glans; altered sensitivity was reported in glans (8%), scrotum (19%), perineum (23%); nobody reported problems in the sexual activity because of these sensitivity disorders
Pfalzgraf *et al*., 2014, (25)	Retrospective	33	Bulbar [17]; penile [16]	Re-do urethroplasties: AU [1]; BMG [26]; staged BMG [4]; mesh graft from thigh [2]	11.8	Overall altered glans sensitivity: 24.2% not disturbing, 9.1% disturbing: bulbar, 11.8% not disturbing, 5.9% disturbing; penile: 37.5% not disturbing, 12.5% disturbing
Patel *et al*., 2015, (27)	Retrospective	22/33**	Penile	BMG staged repair	6.3 (after 2nd stage)	36% decreased penile sensitivity, 9% increased penile sensitivity, 55% no sensitivity changes
Beysens *et al*., 2015, (37)	Prospective	45 at 6 weeks; 25 at 6 months	Bulbar	AU [31]; free graft urethroplasty [16] [12 prepuce, 4 BMG]	23.3	62.2% and 52% reported altered genital sensitivity at 6 weeks and 6 months, respectively. No significant differences between groups. 1 patient (AU group) had cold glans at 6 weeks. No cold glans was reported at 6 months
Spencer *et al*., 2017, (35)	Retrospective	42/73	Panurethral	One-sided urethral dissection, penile invagination, dorsal BMG onlay	44	10% decreased penile sensitivity
Furr *et al*., 2019, (38)	Retrospective	179	Bulbar	AU [96]; dorsal BMG [DBG] [32]	DBG 51.4; AU 63.3	Decreased glans filling: 10.6% AU *vs.* 9.4% DBG (P=1); cold glans: 5.2% AU *vs.* 0% DBG (P=0.19); decreased penile sensation 23.4% AU *vs.* 18.8% DBG (P=0.48)

*, sexually active; **, completed the questionnaires. AU, anastomotic urethroplasty; BMG, buccal mucosa graft; DBG, dorsal buccal grafting.

evaluated preoperatively and after 6 months postoperatively using IPSS, IIEF, and an urethroplasty quality of life survey, Maciejewski *et al.* (44) found that only penile shortening (OR 2.26) and chordee (OR 2.26) retained statistical significance as independent predictors of patient satisfaction in multivariate analysis. These complications following urethroplasty cause significant unexpected patient distress, leading to a reduction in the overall satisfaction score which further emphasizes the need for standardized questionnaires that consider patient-reported sexual function and genital condition for evaluation of urethroplasty outcomes.

In a similar way, Kessler *et al.* (36) in 2002 reported that severe penile curvature, marked penile shortening and severe erection deterioration greatly influenced patient's dissatisfaction with surgical outcomes. They suggested that outcomes after urethral surgery should not only be assessed by objective criteria such as urinary peak flow, post void residual urine, or radiological appearance, but also through subjective measures, like post void dribbling, milking of urethra, cosmetic appearance, erection deterioration, penile curvature and shortening and impairment of sexual life. This was in line with their finding that only 78% of patients in whom urethroplasty was considered successful were satisfied with the outcome of urethral surgery.

Conclusions

It is well proven that anterior urethral surgery can have consequences over sexual function, affecting erection, ejaculation and/or genital sensitivity. Sexual health is an important issue for patients undergoing urethral reconstruction. Deterioration of sexual function may cause postoperative dissatisfaction, even when a patent urethra is achieved. Penile urethra interventions, long panurethral urethroplasties, and revision surgeries pose the greater risks.

The functional benefit of non-transecting approach and grafting techniques in bulbar urethra remain controversial when compared with EPA. Prospective well designed and conducted studies are required to clarify those aspects.

Pre- and post-operative evaluation of sexual function using validated tools is of outmost importance. It can provide objective information for adequate preoperative counselling, outcome evaluation and early complication detection.

Footnote

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