Curr Urol Rep (2014) 15:424
DOI 10.1007/s11934-014-0424-3

UROSURGERY (A STENZL, SECTION EDITOR)

Graft Surgery in Extensive Urethral Stricture Disease

Miroslav L. Djordjevic

Published online: 17 June 2014

Abstract Surgical treatment of long urethral stricture disease remains one of the most challenging problems in urology. In recent years there has been continuous discussion with regard to the etiology, location, length, and management of extensive urethral stricture disease. Various tissues such as genital and extragenital skin, buccal mucosa, lingual mucosa, small intestinal submucosa, and bladder mucosa have been proposed for urethral reconstruction. The most frequent questions pertain to the optimal technique for urethroplasty and the optimal graft for substitution urethroplasty, as judged by both patient satisfaction and outcome success. We review the recent literature with respect to any new information on graft urethroplasty for extensive urethral stricture.

Keywords Urethral stricture · Penile urethra · Bulbar urethra · Urethral surgery · One-stage urethroplasty · Buccal mucosa

Introduction

Despite recent developments in surgical methods of urethroplasty, the management of extensive urethral stricture disease remains one of the most challenging problems in urology. Treatment of urethral strictures is complex and is dependent upon the characteristics of the stricture [1]. Management of anterior urethral strictures usually starts with minimally invasive procedures such as urethral dilation or urethrostomy, and continues to more aggressive procedures such as anastomotic or substitute urethroplasty [2]. Incision or splitting of the stenotic urethral segment, with spontaneous healing, remains a less-than-promising method, with a high rate of restenosis. To date, numerous techniques including catheterization, repeated dilation, brachytherapy, and intraurethral use of various anti-fibrotic agents have been employed to counter the process of wound contraction or to regulate the extracellular matrix [3, 4]. Unfortunately, none of these techniques or agents has demonstrated sufficient evidence of efficacy. Data show that there is no difference between urethral dilation and internal urethrostomy in terms of long-term outcomes; success rates range widely, from 8 % to 80 %, with long-term success rates of 20–30 %. For both of these procedures, the risk of recurrence is greater for men with longer strictures, penile urethral strictures, multiple strictures, presence of infection, or history of prior procedures. Analysis has shown that repeated use of urethrostomy is neither clinically effective nor cost-effective in these patients. Tian et al. [5] concluded that there was no unique optimum solution suitable for all conditions, and that the clinical decision with regard to the stricture recurrence prevention technique should be carefully tailored to each individual patient. Lubahn et al. [6] found that most patients who were on intermittent dilation or self-dilation described difficulty and pain as moderate and inconvenience as low, but reported poor quality of life.

Less invasive procedures such as urethrostomy, stenting, or dilation continue to play a role in the treatment of urethral strictures as a first-line option in select patients [7]. However, superior long-term outcomes are seen when the anterior urethral strictures are treated with open reconstructive surgery rather than dilation or urethrostomy [8, 9]. There are techniques that have been utilized for urethroplasty, depending upon the location, length, and character of the stricture. Successful management of urethral strictures requires detailed knowledge of anatomy and pathophysiology, as well as proper selection of reconstructive techniques for each unique patient [10]. For long penile strictures, a ventral onlay procedure using a skin graft can be considered except in cases of lichen

This article is part of the Topical Collection on *Urosurgery*

M. L. Djordjevic (✉)
Department of Urology, School of Medicine, University of Belgrade, Tirsova 10, Belgrade, Serbia 11000
e-mail: djordjevic@uromiros.com

sclerosis or cripple hypospadias, when an onlay procedure utilizing oral mucosa provides the best results using either a one-stage or two-stage approach [11, 12•, 13, 14]. In patients with long bulbar strictures, if augmentation urethroplasty is not feasible, a substitution urethroplasty should be considered, using either a flap or oral mucosa graft via dorsal, lateral, or ventral onlay approach [15–18].

Type of Graft

Various grafts, including genital or extragenital skin, oral mucosa, bladder mucosa, and colonic mucosa, have been used for urethral reconstruction [2, 19–21]. In the last few decades, oral mucosa and genital skin have emerged as the gold standard substitute materials for the repair of urethral stricture, although there has been rapid progress in the development of engineered-tissue urethral graft. Use of genital skin is contraindicated in cases with lichen sclerosis since the condition tends to recur in skin, and in this setting, oral mucosa represents the tissue of choice. This mucosa is adapted to constant moistness and is resilient to skin disease, in addition to having a privileged immunology [11, 22].

A buccal mucosa graft harvested from the cheek is currently recognized as the best urethral substitute for a long urethral stricture amenable to excision and primary anastomosis. Oral mucosa grafts may also be harvested from the tongue (lingual mucosa), presenting a good alternative with an equivalent outcome to urethroplasty [23–25]. Tissue characteristics of both buccal and lingual mucosa are similar: thick epithelium, thin lamina propria, rich vascularization, and good elasticity. Additional advantages of these materials include excellent graft take and small contracture, as well as the fact that they are readily available and easily harvested [26].Harvesting of longer lingual mucosa grafts (exceeding 7 cm), however, is associated with long-term speech morbidity. Sharma et al. [27] concluded that the cheek remained the primary donor site for oral mucosa, and that lingual mucosa harvest should be restricted to cases in which buccal mucosa harvesting is not possible.

Reported complications of oral mucosa harvesting include pain, perioral numbness, tightness of the mouth, persistent mouth opening difficulty, changes in salivary function, and motor deficit [28, 29, 30•]. Nevertheless, Barbagli et al. concluded that harvesting from the cheek, followed by donor site closure, represented a safe and simple procedure and reported high patient satisfaction. In a survey of 295 patients, 98.4 % reported that they would undergo the surgery again. Similar results were reported in the latest multivariable analysis of a cohort of 553 patients who underwent oral mucosal graft harvesting. Late complications analysis showed that 95.5 % of patients declared that the surgical closure of the wound had not caused any difficulty in mouth opening or problems with smiling (98.2 %) and/or dry mouth (95.8 %). Overall, 98.2 % of patients were satisfied with the procedure [31].

However, full reconstruction of the long urethral stricture cannot be accomplished through the use of oral mucosa alone, as the size and total length of the grafts are quite limited. Meeks et al. [32] showed that in long lichen sclerosus stricture, nongenital skin – such as abdominal skin – provides a useful alternative graft for urethroplasty when the oral mucosa is unavailable or insufficient. Xu et al. [33] reported success in 85.7 % of 36 patients with long urethral stricture using colonic mucosa. Similarly, Mundy and Andrich [34] described the use of grafts from the stomach, ileum, and colon in complex bulbomembranous stricture. Urethral tissue engineering is an emerging field, and acellular matrix grafts made from porcine small intestinal submucosa offer a promising alternative to current grafts. Some authors have reported high success rates at relatively short follow-up periods [35]. Palminteri et al. [36, 37] reported long-term experience (mean follow-up period, 71 months) with 25 patients who underwent small intestinal submucosa graft urethroplasty for bulbar strictures. Although there were no complications such as infection or rejection, the reported success rate was only 76 %, and for strictures exceeding 4 cm, the failure rate was 100 %. The authors suggested that this graft was useful only in short- or medium-length bulbar strictures with mild spongiofibrosis. Because long-term follow-up data has demonstrated less effective results than those achieved with oral mucosa grafts, the use of small intestinal submucosa grafts should be considered an option for patients who refuse oral mucosa harvesting or who have undergone an oral mucosa grafting procedure that failed. Lastly, Mangera and Chapple [38•, 39] evaluated the progress that has been made in finding a tissue-engineered substitute for the human urethra, discussed different approaches to developing these grafts, and reviewed their results in human studies. They concluded that tissue-engineered grafts may facilitate the management of lengthy urethral strictures requiring oral mucosa substitute urethroplasty.

Penile Urethral Strictures

Penile strictures are different from bulbar urethral strictures. In the penile urethra, excision of the stenotic segment and direct anastomosis is almost impossible without postoperative penile curvature. With regard to the repair of penile or panurethral strictures, the debate revolves around the issues of one- versus two-stage procedure and ventral versus dorsal approach. One-stage graft urethroplasty has been suggested in patients with a remaining urethral plate or acceptable width, normal penis, penile skin, corpus spongiosum and dartos fascia. Conversely, in patients with several failed penile and/or urethral surgeries, where penile entities are not available for urethral reconstruction, a multistage urethroplasty is generally recommended

[12•]. The choice of reconstructive technique is based on the etiology of the disease and the condition of the penis and urethra [40]. Repeated internal urethrostomies or open surgery can lead to severe spongiofibrosis, penile curvature, and sometimes complete closure of the urethral lumen. The situation is probably worst in hypospadias, as these usually also involve a deficiency in corpus spongiosum, and the available penile skin is often insufficient for the repairs needed. A small glans can also make the reconstruction more difficult. There have been numerous discussions on the positioning of the buccal mucosal graft in urethral reconstruction. The graft could be placed on the dorsal or the ventral side of the urethra. Although ventral placement was described first, dorsal placement has been gaining popularity since Barbagli et al. reported their approach. Enlargement of the urethral plate can usually be achieved using the Asopa, Barbagli, or Kulkarni technique.

The Asopa technique consists of dorsal grafting through the ventral urethrostomy [41]. It is based on the principle described by Hayes and Malone [42], who recommended laying a buccal mucosa graft into the longitudinally incised urethral plate in patients after failed hypospadias repair. In this approach, the strictured urethra is opened by a ventral midline incision, the urethral plate is longitudinally incised on the dorsal side, the graft is positioned in place to enlarge the plate, and graft-augmented urethra is ventrally closed. This technique was also reported by four other authors [36, 43–45]. A total of 111 cases have been described, with an average follow-up of 27.6 months and an average success rate of 87.34 %.

Barbagli described a dorsal approach to the stenotic urethra. In the original dorsal graft techniques, the urethra is circumferentially mobilized from the cavernous bodies to expose its dorsal surface, and the graft is fixed over the underlying tunica albuginea. Proponents of the dorsal approach argue that it offers the best conditions for graft survival since the buccal mucosa is stretched and fixed to the cavernous bodies, which promotes survival and prevents retraction of the graft. In ventral grafting techniques, there is no firm support for the buccal mucosal graft. Thus, retraction or sacculation is theoretically more likely, although well-vascularized spongy tissue certainly provides good nutritional support to the graft [46]. In a modification of the original technique described by Barbagli, Riechardt et al. were able to achieve better visualization of the mucosal margins during the creation of the anastomosis, thus simplifying the procedure [47]. Success rates of this novel technique were compared to those of the original Barbagli procedure in 47 patients over a three-year period [48•] to determine whether the Barbagli or Asopa approach was preferable for the management of long anterior urethral strictures. Aldaqadossi et al. concluded that success rates were comparable between the two approaches. Pahwa et al. [49] reported similar results in their comparative study, but with a short follow-up of 12 months. However, Asopa's technique was found to be easy to carry out, had a shorter operative time and less blood loss, and was associated with fewer complications for anterior urethral stricture repair [45].Xu et al. [50] recently reported excellent success rates (88.9 %) using the Barbagli approach in the treatment of 54 patients with long urethral strictures (median, 12.5 cm; range, 6–18 cm) and long mean follow-up of 38.7 months. Hudak et al. [51, 52] described an additional approach that utilized overlapping dorsal and ventral buccal mucosa grafts, without ballooning or diverticula formation, reporting a success rate of almost 90 %.

The Kulkarni technique presented the use of a one-sided anterior urethroplasty utilizing the oral mucosa to avoid circumferential urethral mobilization and to preserve the lateral vascular supply to the urethra. Using this approach, Kulkarni et al. reported 92 % successful outcome at a mean follow-up of 22 months [53].

Bulbar Urethral Strictures

Stricturotomy with oral mucosal grafting remains the gold standard for the treatment of a long bulbar urethral stricture with relatively well-preserved urethral lumen and limited spongiofibrosis, demonstrating a success rate of almost 90 %. In a comparison of reconstructive approaches, there is no significant difference between the average success rates of the dorsal and the ventral onlay procedures (88.4 % and 88.8 % at 42.2 and 34.4 months in 934 and 563 patients, respectively) [2]. The primary question in this repair procedure is whether or not to transect the bulbar urethra during bulbar stricture repair. While high rates of success were reported with transecting techniques, this was called into question when sexual disturbances were described by some authors [54, 55•]. To dissect or not to dissect remains the subject of ongoing debate, with no general recommendations having been formulated thus far [56]. Al-Qudah and Santucci [57] reported that oral mucosal graft urethroplasty showed superior success and fewer complications, including sexual dysfunction, than anastomotic repair. The incidence of sexual dysfunction after anastomotic repair is related to the proximity of the bulbar urethra to the cavernous nerves [58]. Palminteri et al. [59•] evaluated the pre- and postoperative parameters of quality of sexual life in 52 patients who underwent ventral graft urethroplasty, with none of the patients reporting postoperative problems with erection or ejaculation. Since there is no need for urethral mobilization or urethral transection during ventral graft urethroplasty, postoperative erectile dysfunction and other sexual disorders are avoided.

Another dilemma is where to place the graft – ventrally or dorsally. Ventral placement of the graft has the advantage of limited urethral mobilization and preservation of cavernosospongiosal arteries. Disadvantages include increased blood

loss, incidence of diverticula formation, and failure rate. Dorsal placement provides a more stable, well-vascularized recipient location for the graft, but requires a more extensive mobilization of the urethra, which may lead to injury of neurovascular components. Two retrospective single-institution series have compared the two approaches. Andrich et al. [60] concluded that dorsal onlay was associated with a higher rate of success in 71 patients with bulbar stricture. Conversely, Barbagli [61] reported no difference in success rates between the two procedures. In a review of 103 patients who underwent bulbar urethroplasty, Figler et al. [62] were unable to conclude whether either dorsal or ventral graft position was inherently superior. They also found that patients with diabetes may be more likely to require additional procedures after primary bulbar reconstruction. Chen et al. [63•] recommended the use of a double-sided graft technique for very long bulbar urethral strictures. They combined a ventral onlay buccal mucosa graft and a dorsal inlay full-thickness skin graft, and found improved success rates compared to buccal mucosa urethroplasty alone. Following ventral opening, if the bulbar urethral plate is found to be narrow, this could pose a problem, especially with regard to suturing an oral graft to such a narrow plate. Barbagli et al. [64] recommend anastomosing the graft only to the left side of the remaining urethral mucosa. On the right side, the graft was sutured directly to the spongiosal tissue.

Failed Hypospadias Repair

Management of urethral stricture after failed hypospadias repair represents a major challenge, and there is a continual search for new and better solutions. Urethral strictures caused by infection, trauma, instrumentation, or a urinary catheter predominantly involve normal penile tissues, and are usually suitable for urethral reconstruction. Conversely, patients with failed hypospadias usually do not have a sufficient amount of local tissue that can be used for reconstruction, meaning that an extragenital substitution graft must be applied. The most common problems after failed hypospadias repair are inadequate vascular supply and deficient spongiosal tissue necessary for better graft survival. The post-hypospadiac urethra is often thin, vulnerable, and firmly attached to the cavernous bodies. Firm scar formation and the paucity of genuine spongy tissue make urethral mobilization a hazardous, problematic procedure.

In light of these facts, the majority of studies have focused on staged urethral repair for failed hypospadias. Gill and Hameed performed staged repair in 100 patients, using different grafts. With a minimum of one year follow-up, recurrent strictures were registered in six patients [65]. Barbagli et al. [14] reported a higher success rate using buccal mucosa (82 %) than skin grafts (50 %). In another study, Barbagli et al. [13] analyzed 1,176 patients after over a period of 10 years. They found that failed hypospadias repair was corrected in 65 % of the patients in a one-stage procedure and 35 % in a staged procedure using oral or skin grafts. Djordjevic et al. [66] reported one-stage urethroplasty in 15 patients with urethral stricture after failed hypospadias repair. Hanging of the buccal mucosal graft to periurethral tissue was found to prevent graft folding; only one fistula was reported postoperatively.

Staged urethroplasty may occasionally be inevitable in patients with several failed attempts. Excision of all scar tissue and use of buccal mucosal or skin grafts are critical for a successful outcome. Generally, urethral strictures after hypospadias repair are among the most difficult complications to treat, which underscores the importance of long-term follow-up in children with post-hypospadias repair.

Staged Urethroplasty

Most cases of urethral reconstruction may be managed with single-stage surgery. However, strictures caused by inflammatory, atrophic, or obliterative effects of lichen sclerosus may be best managed with staged urethroplasty [2, 7, 11, 12•]. This is especially effective for anterior urethral strictures, applying the previously described principles. Bulbar urethral strictures are usually repaired in a one-stage procedure. Rarely, complications such as bulbar urethral necrosis, urethral stone infection, or migration and incorporation of the metal urethral stents from previous repairs present indications for staged correction. The principle remains the same: the affected urethra is opened, present foreign bodies are removed; a new "urethral plate" is created with either local flaps or grafts, followed by the creation of urethrostomy. The key to successful repair is waiting long enough so that the skin is supple, and a classic error is performing the second stage too early. The second stage should be performed after the graft has healed, which usually takes four to six months. The procedure is then completed by mobilizing the urethral plate from the surrounding skin to allow tubularization of the neourethra over the catheter.

Johanson's surgical principles, which were introduced in 1953 [67], are still in use today either directly or indirectly. The original Johanson approach involved marsupialization of the urethral stricture and joining it with surrounding penile skin to create a urethral plate. The second stage included tubularization of the dorsal urethral plate. In addition, sufficient skin was turned inward to create a urethra with an acceptable lumen. The technique by Schreiter, which is a modification of original Johanson's technique, uses a meshed skin graft fixed to the dartos and urethral edges to create the urethral plate [68]. After 6–12 months of graft maturation, the urethral plate is tubularized in the standard fashion. Buccal

mucosa grafts represent the optimal solution in staged urethroplasty using the Johanson principle.

Conclusions

Surgical treatment of urethral strictures is continually evolving. Although numerous strategies are available, there is still no single optimum solution suitable for all conditions. The clinical selection of stricture recurrence prevention techniques should be carefully tailored to each individual patient. The reconstructive urologist must be familiar with a variety of techniques to ensure the choice of the best procedure as dictated by situation. As current available studies provide insufficient evidence to establish firm guidelines, further efforts are needed to address this interesting but challenging issue.

Acknowledgments This paper is supported by Ministry of Science, Republic of Serbia, Project No. 175048.

Compliance with Ethics Guidelines

Conflict of Interest Dr. Miroslav L. Djordjevic declares no potential conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- Of importance

1. Lumen N, Hoebeke P, Willemsen P, et al. Etiology of urethral stricture disease in the 21st century. J Urol. 2009;182:983–7.
2. Mangera A, Patterson JM, Chapple CR. A systematic review of graft augmentation urethroplasty techniques for the treatment of anterior urethral strictures. Eur Urol. 2011;59:797–814.
3. Greenwell TJ, Castle C, Andrich DE, et al. Repeat urethrostomy and dilation for the treatment of urethral stricture and neither clinically effective nor cost-effective. J Urol. 2004;172:275–7.
4. Buckley JC, Heyns C, Gilling P, Carney J. Dilation, internal urethrotomy, and stenting of male anterior urethral strictures. Urology. 2014;83:S18–22.
5. Tian Y, Wazir R, Yue X, Wang K, Li H. Prevention of stricture recurrence following urethral endoscopic management: what do we have? J Endourol. 2014;28:502–508.
6. Lubahn JD, Zhao LC, Scott JF, Hudak SJ, Chee J, Terlecki R, et al. Poor quality of life in patients with urethral stricture treated with intermittent self-dilation. J Urol. 2014;191:143–7.
7. Mangera A, Chapple C. Management of anterior urethral stricture: an evidence-based approach. Curr Opin Urol. 2010;20:453–8.
8. Santucci R, Eisenberg L. Urethrotomy has a much lower success rate than previously reported. J Urol. 2010;183:1859–62.
9. Breyer BN, McAninch JW, Whitson JM, et al. Multivariate analysis of risk factors for long-term urethroplasty outcome. J Urol. 2010;183:613–7.
10. Hampson LA, McAninch JW, Breyer BN. Male urethral strictures and their management. Nat Rev Urol. 2014;11:43–50.
11. Palminteri E, Brandes SB, Djordjevic ML. Urethral reconstruction in lichen sclerosus. Curr Opin Urol. 2012;22:478–83.
12.• Riechardt S, Dahlem R, Fisch M. Urethral 'cripples': two stage procedures. Curr Opin Urol. 2012;22:484–6. *The good review of all aspects related to urethral cripple cases and recommendations for repair.*
13. Barbagli G, Perovic S, Djinovic R, et al. Retrospective descriptive analysis of 1,176 patients with failed hypospadias repair. J Urol. 2010;183:207–11.
14. Barbagli G, De Angelis M, Palminteri E, et al. Failed hypospadias repair presenting in adults. Eur Urol. 2006;49:887–94.
15. Morey A. Urethral stricture is now an open surgical disease. J Urol. 2009;181:953–4.
16. Barbagli G, Guazzoni G, Lazzeri M. One-stage bulbar urethroplasty: retrospective analysis of the results in 375 patients. Eur Urol. 2008;53:828–33.
17. Dubey D, Vijjan V, Kapoor R, et al. Dorsal onlay buccal mucosa versus penile skin flap urethroplasty for anterior urethral stricture: result from a randomized prospective trial. J Urol. 2007;178:2466–9.
18. Barbagli G, Morgia G, Lazzeri M. Dorsal onlay skin graft bulbar urethroplasty: long –term follow-up. Eur Urol. 2008;53:628–33.
19. Kinkead TM, Borzi PA, Duffy PG, Ransley PG. Long-term follow-up of bladder mucosa graft for male urethral reconstruction. J Urol. 1994;151:1056–8.
20. Jordan GH. Scrotal and perineal flaps for anterior urethral reconstruction. Urol Clin N Am. 2002;29:411–6.
21. Xu YM, Qiao Y, Sa YL, et al. Urethral reconstruction using colonic mucosa graft for complex stricture. J Urol. 2009;182:1040–3.
22. Dubey D, Sehgal A, Srivastava A, et al. Buccal mucosal urethroplasty for balanitis erotica obliterans related urethral strictures: the outcome of 1 and 2-stage techniques. J Urol. 2005;173:463–6.
23. Simonato A, Gregori A, Lissiani A, et al. The tongue as an alternative donor site for graft urethroplasty: a pilot study. J Urol. 2006;175:589–92.
24. Simonato A, Gregori A, Ambruosi C, et al. Lingual mucosal graft urethroplasty for anterior urethral reconstruction. Eur Urol. 2008;54:79–85.
25. Barbagli G, De Angelis M, Romano G, et al. The use of lingual mucosal graft in adult anterior urethroplasty: surgical steps and short-term outcome. Eur Urol. 2008;54:671–6.
26. Song LJ, Xu YM, Lazzeri M, Barbagli G. Lingual mucosa grafts for urethroplasty: a review. BJU Int. 2009;104:1052–6.
27. Sharma AK, Chandrashekar R, Keshavamurthy R, et al. Lingual versus buccal mucosa graft urethroplasty for anterior urethral stricture: a prospective comparative analysis. Int J Urol. 2013;20:1199–203.
28. Dublin N, Stewart LH. Oral complications after buccal mucosa harvest for urethroplasty. BJU Int. 2004;94:867–9.
29. Markiewicz MR, De Santis JL, Margarone JE, et al. Morbidity associated with oral mucosa harvest for urological reconstruction: an overview. J Oral Maxillofac Surg. 2008;66:739–44.
30.• Rourke K, McKinny S, St. Martin B. Effect of wound closure on buccal mucosal graft harvest site morbidity: result of a randomized prospective trial. Urology. 2012;79:443–7. *Randomized study about morbidity after harvesting of buccal mucosa graft.*
31. Barbagli G, Fossati N, Sansalone S, et al. Prediction of early and late complication after oral mucosal graft harvesting: multivariable

analysis from a cohort of 553 consecutive patients. J Urol. 2014;191:688–693.
32. Meeks JJ, Erickson BA, Fetchev P, et al. Urethroplasty with abdominal skin grafts for long segment urethral stricture. J Urol. 2010;183:1880–4.
33. Lee YT, Cho TW, Jeong HS, et al. Reconfigured sigmoid colon neourethra: substitution of refractory posterior urethral stricture. Urology. 2005;65:157–9.
34. Mundy AR, Andrich DE. Entero-urethroplasty for the salvage of bulbo-membranous stricture disease or trauma. BJU Int. 2010;105:1716–20.
35. Xu YM, Fu Q, Sa YL, et al. Outcome of small intestinal submucosa graft for repair of anterior urethral strictures. Int J Urol. 2013;20:622–9.
36. Palminteri E, Berdondini E, Colombo F, et al. Small intestinal submucosa (SIS) graft urethroplasty: short-term results. Eur Urol. 2007;51:1695–701.
37. Palminteri E, Berdondini E, Fusco F, et al. Long-term results of small intestinal submucosa graft in bulbar urethral reconstruction. Urology. 2012;79:695–701.
38.• Mangera A, Chapple CR. Tissue engineering in urethral reconstruction-an update. Asian J Androl. 2013;15:89–92. *The current literature review on the different ways of tissue engineering in urethral reconstruction*.
39. Li C, Xu YM, Liu ZS, Li HB. Urethral reconstruction with tissue engineering and RNA interference techniques in rabbits. Urology. 2013;81:1075–80.
40. Barbagli G, Lazzeri M. Urethral reconstruction. Curr Opin Urol. 2006;16:391–5.
41. Asopa HS, Garg M, Singhal GG, et al. Dorsal free graft urethroplasty for urethral stricture by ventral sagittal urethrostomy approach. Urology. 2001;58:657–9.
42. Hayes MC, Malone PS. The use of a dorsal buccal mucosal graft with urethral plate incision (Snodgrass) for hypospadias salvage. BJU Int. 1999;83:508–9.
43. Singh PB, Das SK. Kumar, et al. Dorsal onlay lingual mucosal graft urethroplasty: comparison of two techniques. Int J Urol. 2008;15:1002–5.
44. Pisapati VLNM, Paturi S, Bethu S, et al. Dorsal buccal mucosal graft urethroplasty for anterior urethral stricture by Asopa technique. Eur Urol. 2009;56:201–6.
45. Aldaqadossi H, El Gamal S, El-Nadey M, et al. Dorsal onlay (Barbagli technique) versus dorsal inlay (Asopa technique) buccal mucosal graft urethroplasty for anterior urethral stricture: a prospective randomized study. Int J Urol. 2014;21:185–8.
46. Barbagli G, Selli C, di Cello V, Mottola A. A one-stage dorsal free-graft urethroplasty for bulbar urethral strictures. Br J Urol. 1996;78:929–32.
47. Riechardt S, Pfalzgraf D, Dahlem R, Fisch M. Surgery illustrated-focus on details: dorsal buccal mucosal inlay for penile urethroplasty. BJU Int. 2009;103:1444–7.
48.• Pfalzgraf D, Kluth L, Isbarn H, et al. The Barbagli technique: 3-year experience with a modified approach. BJU Int. 2013;1:132–6. *Good comparative study between results of original Barbagli technique and author's modification*.
49. Pahwa M, Gupta S, Pahwa M, et al. A comparative study of dorsal buccal mucosa graft substitution urethroplasty by dorsal urethrostomy approach versus ventral sagittal urethrostomy approach. Adv Urol. 2013. doi:10.1155/2013/124836.
50. Xu YM, Feng C, Sa YL, et al. Outcome of 1-stage urethroplasty using oral mucosal grafts for the treatment of urethral strictures associated with genital lichen sclerosus. Urology. 2014;83:232–6.
51. Hudak SJ, Lubahn JD, Kulkarni S, Morey AF. Single-stage reconstruction of complex anterior urethral stricture using overlapping dorsal and ventral buccal mucosal graft. BJU Int. 2012;110:592–6.
52. Tausch TJ, Morey AF. Editorial comment. Int J Urol. 2014;21:189.
53. Kulkarni S, Barbagli G, Sansalone S, Lazzeri M. One-sided anterior urethroplasty: a new dorsal onlay graft technique. BJU Int. 2009;104:1150–5.
54. Fisch M. Editorial comment on urethra reconstruction. Curr Opin Urol. 2012;22:445–6.
55.• Lee YJ, Kim SW. Current management of urethral stricture. Korean J Urol. 2013;54:561–9. *Excellent review of current techniques for urethral stricture disease*.
56. Barbagli G, Sansalone S, Romano G, Lazzeri M. Bulbar urethroplasty: transecting vs. nontransecting techniques. Curr Opin Urol. 2012;22:474–7.
57. Al-Qudah HS, Santucci RA. Buccal mucosa onlay urethroplasty versus anastomotic urethroplasty for short urethral strictures: which is better? J Urol. 2006;175:103 (abstract 313).
58. Erickson BA, Granieri MA, Meeks JJ, et al. Prospective analysis of erectile dysfunction after anterior urethroplasty: incidence and recovery of function. J Urol. 2010;183:657–61.
59.• Palminteri E, Berdondini E, De Nunzio C, et al. The impact of ventral oral graft bulbar urethroplasty on sexual life. Urology. 2013;81:891–8. *This paper highlights the most important facts about sexual life after bulbar urethral stricture reconstruction*.
60. Andrich DE, Leach CJ, Mundy A. The Barbagli procedure gives the best results for patch urethroplasty of the bulbar urethra. BJU Int. 2001;88:385–9.
61. Barbagli G, Palminteri E, Guazzoni G, et al. Bulbar urethroplasty using buccal mucosa grafts placed on the ventral, dorsal or lateral surface of the urethra: are results affected by the surgical technique? J Urol. 2005;174:955–8.
62. Figler BD, Malaeb BS, Dy GW, et al. Impact of graft position on failure of single-stage bulbar urethroplasties with buccal mucosa graft. Urology. 2013;82:1166–70.
63.• Chen ML, Odom BD, Johnson LJ, Santucci RA. Combining ventral buccal mucosa graft onlay and dorsal full thickness skin graft inlay decreases failure rates in long bulbar strictures (>6 cm). Urology. 2013;81:899–903. *This paper describes novel technique with combining of skin and buccal mucosa grafts*.
64. Barbagli G, Montorsi F, Guazzoni G, et al. Ventral oral mucosal onlay graft urethroplasty in nontraumatic bulbar urethral strictures: surgical technique and multivariable analysis of results in 214 patients. Eur Urol. 2013;64:440–7.
65. Gill NA, Hameed A. Management of hypospadias cripples with two-staged Bracka's technique. J Plast Reconstr Aesthet Surg. 2011;64:91–6.
66. Djordjevic ML, Kojovic V, Bizic MR, et al. "Hanging" of the buccal mucosal graft for urethral stricture repair after failed hypospadias. J Urol. 2011;185:2479–82.
67. Johanson B. The reconstruction in stenosis of the male urethra. Z Urol. 1953;46:361–75.
68. Schreiter F. Mesh-graft urethroplasty: our experience with a new procedure. Eur Urol. 1984;10:338–44.