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REVIEW

Male Health

Management of residual penile curvature after penile prosthesis placement

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Residual penile curvature is a common situation following the implantation of a penile prosthesis in patients with Peyronie's disease. Currently, there is a variety of options for the correction of residual curvature, including penile modeling, plication techniques, as well as tunical incision/excision with or without grafting. A literature search of PubMed and Medline databases was conducted from 1964 until 2020, using search terms for all articles in the English language. In this article, we provide a review of the techniques and the outcomes, according to the published literature.

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Keywords: grafting; modeling; penile curvature; penile implant; penile prosthesis; Peyronie's disease; tunical plication

INTRODUCTION

Residual curvature of the penis is a well-known phenomenon after implantation of a penile prosthesis.^{1,2} This may occur in the preexisting context of Peyronie's disease (PD) or following other causes of end-stage erectile dysfunction, such as after radical prostatectomy.³ While it may not be anticipated that there exists a penile curvature in the latter situation, residual curvatures may be so significant and they prevent penetrative intercourse and thus may require treatment at the time of the inflatable penile prosthesis (IPP) or semirigid penile prosthesis insertion.⁴ While some mild curvatures may not require any correction, options for more severe curvatures range from modeling, then plication, to grafting. In this article, we review different available management options for residual penile curvature after penile prosthesis placement.

A literature review was performed with PubMed and Medline, for all articles written in the English language, from 1964 to 2020. The search terms incorporated were PD, residual penile curvature, penile prosthesis, penile modeling, incision/excision with grafting, tunical plication, and sliding technique.

It is a common finding for surgeons to note penile curvature during the insertion of penile implants. Curvature deformities may become apparent in the context of penile prosthesis implantation primarily due to PD or may appear somewhat *de novo*.⁵

PD is a chronic inflammatory disease characterized by excessive accumulation of collagen fibers and other extracellular matrix (ECM) components within the tunica albuginea (TA) of the corpora cavernosa.⁶ The prevalence of PD ranges from 0.4% to 20%, mainly in men aged between 40 years and 70 years.⁷ PD in the chronic phase frequently results in erectile dysfunction (ED), occurring in from 22% to 37.5% of cases.^{8,9} The cause of ED in this context may be

related to several factors including infiltration of the plaque into the neurovascular bundle,¹⁰ as well as veno-occlusive dysfunction from corporal scarring.¹¹ However, it is not only the initial disease process that causes ED. Treatments such as intracavernosal injections are well known to cause fibrosis, with possible subsequent curvature in some men.¹² Curvature correction surgeries such as tunical plication or lengthening/grafting techniques may themselves lead to ED.¹³ Radical prostatectomy has also been associated with the development of penile curvature, possibly due to cavernosal denervation with subsequent fibrotic changes.^{14,15}

Preoperatively, surgeons should be prepared for the likelihood of a curvature. This may be obtained either from the patient history or from an artificial erection test. While many surgeons may not measure penile dimensions perioperatively,¹⁶ it is the authors' opinion that performing this is vital to plan the appropriate surgery for the individual patient and manage their expectations. The penile dimensions (either stretched or erect length) should be measured and note taken of any complexity. Mild curvatures may sometimes not require any treatment, as the implant will self-correct subtle deformities over time.¹⁷ However, when there are curvatures exceeding 45° or 60°, the requirement for correction increases up to 75%–100%.^{18,19} The surgeon must also have an understanding of the various options to correct a curvature in this setting.

MODELING MANEUVER OVER A PENILE PROSTHESIS

Modeling is a well-described maneuver for the correction of residual curvature after penile prosthesis placement.²⁰ This technique involves the following steps: (1) full inflation of the device; (2) clamping of the exit tubing of the device for protection of the pump; (3) steady forceful

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bending of the penile shaft in the opposite direction of curvature for 90 s, this may result in a partial or complete rupture of the plaque; and (4) compression of corporotomy sites for the prevention of cylinder blowout during bending. Successful modeling is defined as an angle of $<10^{\circ}$ – 20° . Modeling may need to be repeated until adequate straightening results.^{2,21,22} This method of straightening was originally described by Wilson and Delk in 1994.²² In his series of 138 patients, he demonstrated success in 118 patients (86%). Eleven patients (8%) required tunical relaxing incisions. Further publications have revealed adequate penile straightening and satisfaction with sexual intercourse ranging from 54%–100% to 88%–100% of cases, respectively (Table 1).^{23–29} Despite the high success rate, it should be borne in mind that this maneuver can lead to complications such as urethral perforation or laceration, which occurs in 2.5%–4% of cases.³⁰ If this occurs, the offending cylinder should be removed and a urethral catheter was placed with delayed replacement of the ipsilateral cylinder after an adequate period of urethral healing, usually 4 weeks–6 weeks. Others have proposed leaving both cylinders in place and simply repairing the urethra directly over a Foley catheter and diverting the urine with a suprapubic cystostomy for 4 weeks–8 weeks before the prosthesis is activated.^{31,32} It is the authors' opinion that surgeons should have a high threshold to perform this maneuver as it is likely to increase the prosthesis infection rate.

The retrospective review of 79 men (11 of whom had PD with intraoperative modeling) showed that the clamping of the tubing is required during modeling. Of the PD cohort, 3 of 11 (27%) patients had device failure, while 3 of 68 (4%) of the non-PD group exhibited device malfunction at an overall mean of 4.3 months.³³

The exact nature of the mechanical failures was not reported. Another study comparing AMS 700 CX® versus Coloplast Titan® showed no difference in mechanical failure following modeling.³⁴ There is limited and conflicting evidence when comparing semirigid and IPP devices. A prospective, nonrandomized cohort of patients who underwent either IPP ($n = 30$) or semirigid implants ($n = 136$) found no significant difference in the immediate end-of-procedure curvature correction. Satisfaction rates were similar with Likert satisfaction scores of 4.3 and 4.4, respectively.³⁵ A retrospective review of 209 PD patients who underwent penile implant surgery concluded that modeling was

more often successful (defined as curvature $<10^{\circ}$ – 20°) with inflatable (84%) versus semirigid (54%) implants.³⁶

PPLICATION TECHNIQUES

Tunical plication is used in patients with residual curvature after implantation of a penile prosthesis after a failed attempt of modeling. It is possible when the patient has a persistent curve of 30° – 60° . Ideally, these patients should not have a short penis nor complexities such as severe waisting. The principle of penile plication is shortening of the longer convex side. The tunica can be left untouched and sutures simply placed to plicate, or tunical excision or incision can occur, with subsequent closure of the defects.³⁷ Several modifications of this concept have been published, including the original Nesbit's procedure,³⁸ Essed-Schroeder technique,³⁹ 16/24-dot,⁴⁰ Heineke-Mikulwicz-based repair (Yachia technique),⁴¹ as well as the Rolle *et al.*⁴² adaptation. The surgeon must consider the following nuances when correcting residual curvature over a penile prosthesis: incision, location of correction, and protection of the implant. If a penoscrotal incision is used, it is common to obtain good access and retraction to visualize most of the penile shaft tunica, if required. This obviously requires some further dissection. During an infrapubic approach, a second incision, either ventral, penoscrotal, or degloving, may need to occur to access the point of maximal curvature, depending on the location and direction of the curve. Once the site of curvature is identified by inflating the implant, the device should be deflated and pushed proximally or removed from the corpora.^{3,28,43–47} While it is possible to place sutures with an implant *in situ*, the possibility of puncture with subsequent mechanical failure exists.

This problem will clearly not occur when using a semirigid device. Plication sutures can then be placed opposite the angle of maximal curvature using the near-far-far-near technique.

One can consider replacing and reinflating the IPP once the sutures are in place, but not tied. The sutures can then be tied and adjusted to optimize the degree of straightening. Outcomes of plication techniques after insertion of the penile prosthesis are summarized in Table 2.

TUNICAL SCRATCH TECHNIQUE FOR CORRECTING RESIDUAL PENILE CURVATURE

Perito and Wilson⁴⁸ first described the scratch technique in 2013 as an effective complementary maneuver to modeling, performed

Table 1: Outcomes of manual modeling after insertion of penile prosthesis

Reference	Year of publication	Patients (n)	Penile prosthesis	Outcome (%)
Wilson <i>et al.</i> ²²	1994	138	AMS 700 CX	Penile straightening (86) Satisfaction with sexual intercourse (90)
Montague <i>et al.</i> ²³	1996	34	AMS 700 CX	Penile straightening (100)
		38	AMS 700 Ultrex	Penile straightening (73.6)
Carson ²⁴	2000	30	AMS 700 CX	Penile straightening (93)
Usta <i>et al.</i> ²⁵	2003	31	AMS 700 CX	Penile straightening (93.5) Satisfaction with sexual intercourse (88)
Chaudhary <i>et al.</i> ²	2005	28	AMS 700 CX	Penile straightening (100)
Kadioglu <i>et al.</i> ²⁷	2008	60	NA	Penile straightening (83.3)
Levine <i>et al.</i> ²⁶	2010	90	AMS 700 CX Titan, Ambicor Alpha I	Penile straightening (79)
Garaffa <i>et al.</i> ³⁶	2011	129	AMS 700 CX, Titan	Penile straightening (84)
		80	AMS 600 Genesis	Penile straightening (54)
Chung <i>et al.</i> ²⁸	2013	138	AMS 700 CX, Titan	Penile straightening (92)
Yafi <i>et al.</i> ²⁹	2016	19	AMS 700 CX, Titan	Penile straightening (100) Satisfaction with sexual intercourse (100)

NA: not available

Table 2: Outcomes of plication techniques for correction residual curvature after implantation penile prosthesis

Reference	Year of publication	Patients (n)	Penile prosthesis	Outcome (%)
Rahman <i>et al.</i> ⁴⁵	2004	5	Alpha I	Penile straightening (100)
Hudak <i>et al.</i> ⁴⁶	2013	11	IPP	Penile straightening (100)
Chung <i>et al.</i> ⁴⁴	2014	18	AMS 700 CX, Titan	Penile straightening (100)
Tausch <i>et al.</i> ⁴³	2015	30	Coloplast Titan	Penile straightening (100) Satisfaction rate (86–95)
Kadioglu <i>et al.</i> ⁴⁷	2018	7	IPP	Penile straightening (100)

IPP: inflatable penile prosthesis

intraoperatively immediately before insertion of a penile prosthesis. This technique involves internal disruption of a PD plaque in a three-dimensional fashion with 12-blade scalpel or pair of sharp Metzenbaum scissors. The basics of this approach were derived from intracorporeal incision technique described by Bella *et al.*⁴⁹ in 2006 using a triangle-shaped scalpel designed for endoscopic carpal tunnel release. There is some evidence that supports the use of postoperative vacuum device following the scratch technique, where after 24 weeks, penile curvature deviation decreased to $8.7^\circ \pm 2.5^\circ$, $9.1^\circ \pm 2.9^\circ$, and $7.7^\circ \pm 0.9^\circ$ for proximal third, middle third, and subcoronal areas, respectively.⁵⁰

TUNICAL INCISION WITH OR WITHOUT GRAFTING

These procedures for the treatment of PD curvature are based on the concept of lengthening of the shorter concave side, by either single or multiple tunical incisions at the point of maximum curvature with or without subsequent grafting of the defect. Indications for these procedures include a residual penile curvature more than 60° , severe hourglass deformity, as well as a lack of adequate penile length.⁵¹ In the case of significant residual curvature that exceeds 30° after two unsuccessful attempts of manual modeling, one can consider tunical relaxing incisions.⁵² Similar to plication, the surgical approach can be either via penoscrotal access, ventral, or circumferential incision. However, the neurovascular bundle should be elevated to ensure its safety. If ventral curvature is present, mobilization of the urethra may be required.^{53,54} For preserving the integrity of the cylinder, relaxing incisions should be performed with low energy electrocautery until complete penile straightening is achieved. Multiple bilateral transverse incisions should be made, each roughly 5 mm–9 mm long. Care should be taken to avoid making these incisions too large or else herniation of the prosthesis may result. In the case of waist deformities, the incisions can be performed in a longitudinal plane.

In some situations, for example, when a significant defect (>1.5 cm–2 cm) is created, the surgeon should consider grafting for the prevention of prosthetic herniation or cylinder aneurysm.

To perform this, the IPP is deflated and potentially removed from the corpora. A semirigid implant can be left *in situ*. The corners of the graft are secured to the tunica albuginea. Running watertight sutures are then performed with 4-0 polydioxanone. Various graft types are available and have been documented in the literature. While there is currently no single universally accepted graft, the ideal properties include cheap, inert, readily available, and simple to implant.

Autologous options include rectus fascia, or saphenous vein, although these incur additional operative time and donor site morbidity. Allografts afford ease of use and reduce operating

time and morbidity. Options include bovine pericardium, fibrin sealant patch (Evarrest), collagen fleece (Tachosil), and oxidized regenerated cellulose (Nu-Knitl), which have been used with reasonable rates of satisfaction and penile straightening.^{55–60} A combination of tunical incision with grafting has been described in several studies, utilizing a collagen fleece (Tachosil). These studies have demonstrated penile straightening rates ranging from 80% to 83.3%, residual curvature rates from 16.7% to 20%, and overall major complication rates of 5.5%–6.9%.^{4,61–63} Outcomes of grafting techniques after insertion of the penile prosthesis are summarized in **Table 3**.

There are both general and specific complications in the context of curvature postimplant, which need to be considered. Herniation of a cylinder through a graft material or tunical incision is a specific issue in these surgeries. The complications of penile implants clearly still exist and include device infection, glans hyposensitivity, cylinder erosion, urethral injury, as well as mechanical failure.^{64,65}

SLIDING TECHNIQUES

The sliding technique was first developed by Rolle *et al.*⁶⁶ in 2012. This approach includes ventrodorsal incisions of the tunica albuginea, penile implant placement, and double dorsal-ventral patch grafting. Its aim is to address simultaneously ED, curvature, and length correction. In the initial series of three patients, none suffered major intraoperative or postoperative complications and resumed sexual activity. In a further cohort of 28 men, the same author published their results of IPP and semirigid devices using porcine small intestinal submucosa and acellular porcine dermal matrix and Tachosil, respectively. There were not any differences regarding penile lengthening or curvature correction between the groups. However, the operative time was less in the semirigid prosthesis group.⁶⁷ Egydio described a modification of the procedure, using Bucks fascia alone for closure, without the need to graft material.^{68,69} The same author more recently describes the multiple-slit technique, whereby multiple small tunical defects replace one large tunical incision.⁷⁰ These techniques have been shown to be effective in correcting penis length and girth in other studies.^{71,72} The sliding techniques have demonstrated high rates of penile straightening ranging from 80% to 100% after insertion of the penile prosthesis. A summary is shown in **Table 4**.

COLLAGENASE CLOSTRIDIUM HISTOLYTICUM (CCH)

CCH is an enzyme, produced by the bacterium *Clostridium histolyticum*, that hydrolyses collagen, and was first used in 1982 for the treatment of PD.⁷³ While CCH is ideally used as a sole treatment, when failure occurs, some men may choose to proceed with curvature correction surgery. There is limited literature available in this context.⁷⁴

DeLay *et al.*⁷⁵ reported on ten patients who underwent curvature corrective surgery, three of whom underwent IPP, following a mean of 5 months after CCH injections. Increased surgical difficulty was encountered in three patients, all of whom had CCH <6 months before curvature surgery. The authors therefore also suggest that curvature correction surgery should be deferred by at least six months following the last injection of CCH. Despite the small sample size, they concluded that surgery following CCH was safe and feasible. There are no studies investigating the use of CCH following penile implants. While Fischer *et al.*^{76,77} reported an animal study whereby CCH reduced fibrotic changes around a silicon implant, one would imagine that the financial implications as well as the risk of damage to IPP cylinders would prevent many surgeons from choosing such an option.

Table 3: Outcomes of grafting techniques after insertion of penile prosthesis

Reference	Year of publication	Patients (n)	Penile prosthesis	Graft	Outcome (%)
Austoni <i>et al.</i> ⁵⁶	2005	80	Soft, axially rigid penile implants	Saphenous vein graft	Penile straightening (100)
Pathak <i>et al.</i> ⁵⁹	2005	15	IPP	Autologous rectus Fascia graft	Penile straightening (100) Satisfaction with sex (100)
Kadioglu <i>et al.</i> ²⁷	2008	20	IPP	Autologous rectus Fascia graft	Penile straightening (100)
Sansalone <i>et al.</i> ⁵⁵	2012	20	AMS 700 CX Coloplast Titan	InteXen	Penile straightening (90) Satisfaction with sex (100)
Silvani <i>et al.</i> ⁵⁷	2012	58	7F Virilis I, 7F Virilis II	Bovine pericardium graft	Penile straightening (100)
Zucchi <i>et al.</i> ⁵⁸	2013	60	10F Virilis, 9.5F SSSA prostheses	Saphenous vein graft	Satisfaction with sex (95)
Hatzichristodoulou ⁴	2018	15	7F Virilis prostheses	Bovine pericardium graft	Penile straightening (100) Satisfaction with sex (80)
Fernández-Pascual <i>et al.</i> ⁶¹	2019	43	Coloplast Titan	TachoSil	Penile straightening (80) Satisfaction with sex (100)
Farrell <i>et al.</i> ⁶²	2019	18	Semi-rigid MPP Genesis Coloplast, AMS 700 CX AMS 700LGX IPP	TachoSil	Penile straightening (82.1) Satisfaction with sex (94.9)
		15	Coloplast Titan	Hemostatic patches (Evarrest, Tachosil, Nu-Knit)	Penile straightening (83.3) Satisfaction with sex (94.4)
			Boston Scientific CX 700	Pericardium allografts	Penile straightening (86.7) Satisfaction with sex (93.3)

IPP: inflatable penile prosthesis; MPP: malleable penile prosthesis

Table 4: Outcomes of sliding techniques for correction residual penile curvature during insertion penile prosthesis

Reference	Year of publication	Patients (n)	Penile prosthesis	Outcome (%)
Rolle <i>et al.</i> ⁶⁶	2012	3	MPP, IPP	Penile straightening (100) Satisfaction with sex (100)
Egydio <i>et al.</i> ⁶⁹	2015	77	Promedon Tube Coloplast Genesis Coloplast Titan AMS 700 CX	Penile straightening (100)
Rolle <i>et al.</i> ⁶⁷	2016	28	Coloplast Genesis AMS 700 CX Coloplast Titan AMS Spectra	Penile straightening (100) Satisfaction with sex (96)
Fang <i>et al.</i> ⁷¹	2018	5	Coloplast Titan Coloplast Genesis	Penile straightening (80) Satisfaction with sex (100)
Egydio <i>et al.</i> ⁷⁰	2018	83	Coloplast Titan Coloplast Genesis	Penile straightening (100)
Clavell-Hernández <i>et al.</i> ⁷²	2018	12	Coloplast Titan Coloplast Genesis	Penile straightening (100)

IPP: inflatable penile prosthesis; MPP: malleable penile prosthesis

Table 5: Summary of techniques used for correction of residual penile curvature

Adjunct Maneuver	Residual Curvature indication	Comment
Nil	Minor: <10°–20°	Minor curves unlikely to be problematic and may straighten over time
Modeling	20°–60°	Small risk of urethral injury
Scratch technique	20°–60°	Can be performed with modeling
Plication	20°–60°, after failed modeling	Will lead to shortened length
Tunical incision techniques	>60°	Can be used for waist or hourglass deformity, with or without grafting
Sliding technique	>60°	For severe penile shortening. Higher risk of tissue ischemia

TREATMENT ALGORITHM

Despite a variety of treatment options, there are no specific guidelines thus far for the management of residual curvature in penile prosthesis surgery. That said, we propose a fairly logical algorithm, which assumes

that curvatures <20° will either not pose a functional issue or will self-correct over time. Modeling or scratch techniques should be employed for residual curvatures between 20° and 60°. Tunical plication should be performed for residual curvatures between 20° and 60° after failed

modeling/scratch. Tunical incisions with or without grafting is reserved for curvature >60°, complex changes such as waisting or hourglass deformities and in case when penile length is a significant concern. Summary and comments of techniques used for correction of residual penile curvature are shown in **Table 5**.

CONCLUSIONS

Following penile implant, a residual curvature is a common finding. While conservative options exist, the surgeon should be aware of the variety of treatment options at their disposal, with an understanding of their place and disadvantages.

AUTHOR CONTRIBUTIONS

DVK, RAB, and VAC performed literature searching and data collection. DVK prepared and designed the manuscript. RJD and GAB contributed to critically revising the manuscript. FG and EEB reviewed and edited the manuscript. All authors read and approved the final manuscript.

COMPETING INTERESTS

All authors declared no competing interests.

REFERENCES

- Krishnapa P, Fernandez-Pascual E, Carballido J, Moncada I, Lledo-Garcia E, *et al*. Surgical management of Peyronie's disease with co-existent erectile dysfunction. *Sex Med* 2019; 7: 361–70.
- Chaudhary M, Sheikh N, Asterling S, Ahmad I, Greene D. Peyronie's disease with erectile dysfunction: penile modeling over inflatable penile prostheses. *Urology* 2005; 65: 760–4.
- Cormio L, Massenio P, Di Fino G, Lucarelli G, Mancini V, *et al*. Long-term results of combined tunica albuginea plication and penile prosthesis implantation for severe penile curvature and erectile dysfunction. *Case Rep Urol* 2014; 2014: 1–3.
- Hatzichristodoulou G. The PICS technique: a novel approach for residual curvature correction during penile prosthesis implantation in patients with severe Peyronie's disease using the collagen fleece TachoSil. *J Sex Med* 2018; 15: 416–21.
- Trost L, Wanzek P, Bailey G. A practical overview of considerations for penile prosthesis placement. *Nat Rev Urol* 2015; 13: 33–46.
- Chung E, Ralph D, Kagioglu A, Garaffa G, Shamsodini A, *et al*. Evidence-based management guidelines on Peyronie's disease. *J Sex Med* 2016; 13: 905–23.
- Carson CC, Levine LA. Outcomes of surgical treatment of Peyronie's disease. *BJU Int* 2014; 113: 704–13.
- Paulis G, Romano G, Paulis A. Prevalence, psychological impact, and risk factors of erectile dysfunction in patients with Peyronie's disease: a retrospective analysis of 309 cases. *Res Rep Urol* 2016; 8: 95–103.
- Mulhall JP, Schiff J, Guhring P. An analysis of the natural history of Peyronie's disease. *J Urol* 2006; 175: 2115–8.
- Burri A, Porst H. The relationship between penile deformity, age, psychological bother, and erectile dysfunction in a sample of men with Peyronie's disease (PD). *Int J Impot Res* 2018; 30: 171–8.
- Chung E, De Young L, Brock GB. Penile duplex ultrasonography in men with Peyronie's disease: is it veno-occlusive dysfunction or poor cavernosal arterial inflow that contributes to erectile dysfunction? *J Sex Med* 2011; 8: 3446–51.
- Chew KK, Stuckey BG, Earle CM, Dhaliwal SS, Keogh EJ. Penile fibrosis in intracavernosal prostaglandin E1 injection therapy for erectile dysfunction. *Int J Impot Res* 1997; 9: 225–30.
- Flores S, Choi J, Alex B, Mulhall JP. Erectile dysfunction after plaque incision and grafting: short-term assessment of incidence and predictors. *J Sex Med* 2011; 8: 2031–7.
- Tal R, Heck M, Teloken P, Siegrist T, Nelson CJ, *et al*. Peyronie's disease following radical prostatectomy: incidence and predictors. *J Sex Med* 2010; 7: 1254–61.
- Ciancio S, Kim E. Penile fibrotic changes after radical retropubic prostatectomy. *BJU Int* 2000; 85: 101–6.
- Blecher GA, Vukina J, Ralph DJ. Penile dimensions: what are surgeons measuring? *Int J Impot Res* 2019; 31: 444–50.
- Anaissie J, Yafi F. A review of surgical strategies for penile prosthesis implantation in patients with Peyronie's disease. *Transl Androl Urol* 2016; 5: 342–50.
- Yafi FA, Sangkum P, McCaslin IR, Hellstrom WJ. Strategies for penile prosthesis placement in Peyronie's disease and corporal fibrosis. *Curr Urol Rep* 2015; 16: 21.
- Mulhall J, Anderson M, Parker M. A surgical algorithm for men with combined Peyronie's disease and erectile dysfunction: functional and satisfaction outcomes. *J Sex Med* 2005; 2: 132–8.

- Wilson S. Surgical techniques: modeling technique for penile curvature. *J Sex Med* 2007; 4: 231–4.
- Berookhim BM, Karpman E, Carrion R. Adjuvant maneuvers for residual curvature correction during penile prosthesis implantation in men with Peyronie's disease. *J Sex Med* 2015; 12: 449–54.
- Wilson SK, Delk JR 2nd. A new treatment for Peyronie's disease: modeling the penis over an inflatable penile prosthesis. *J Urol* 1994; 152: 1121–3.
- Montague DK, Angermeier KW, Lakin MM, Ingleright BJ. AMS 3-piece inflatable penile prosthesis implantation in men with Peyronie's disease: comparison of CX and Ultrex cylinders. *J Urol* 1996; 156: 1633–5.
- Carson CC. Penile prosthesis implantation in the treatment of Peyronie's disease and erectile dysfunction. *Int J Impot Res* 2000; 12: 122–6.
- Usta MF, Bivalacqua TJ, Sanabria J, Koksai IT, Moparty K, *et al*. Patient and partner satisfaction and long-term results after surgical treatment for Peyronie's disease. *Urology* 2003; 62: 105–9.
- Levine LA, Benson J, Hoover C. Inflatable penile prosthesis placement in men with Peyronie's disease and drug-resistant erectile dysfunction: a single-center study. *J Sex Med* 2010; 7: 3775–83.
- Kadioglu A, Sanli O, Akman T, Cakan M, Erol B, *et al*. Surgical treatment of Peyronie's disease: a single center experience with 145 patients. *Eur Urol* 2008; 53: 432–9.
- Chung E, Solomon M, De Young L, Brock GB. Comparison between AMS 700™ CX and Coloplast™ Titan inflatable penile prosthesis for Peyronie's disease treatment and remodeling: clinical outcomes and patient satisfaction. *J Sex Med* 2013; 10: 2855–60.
- Yafi FA, Hatzichristodoulou G, Wang J, Anaissie J, Sikka SC, *et al*. Outcomes of surgical management of men with Peyronie's disease with hourglass deformity. *Urology* 2016; 91: 119–23.
- Ziegelmann MJ, Farrell MR, Levine LA. Modern treatment strategies for penile prosthetics in Peyronie's disease: a contemporary clinical review. *Asian J Androl* 2020; 22: 51–9.
- Scherzer ND, Dick B, Gabrielson AT, Alzweri LM, Hellstrom WJ. Penile prosthesis complications: planning, prevention, and decision making. *Sex Med Rev* 2019; 7: 349–59.
- Anele UA, Le BV, Burnett AL. Suprapubiccystostomy for the management of urethral injuries during penile prosthesis implantation. *Sex Med* 2014; 2: 178–81.
- DiBlasio CJ, Kurta JM, Botta S, Malcolm JB, Wan JY, *et al*. Peyronie's disease compromises the durability and component-malfunction rates in patients implanted with an inflatable penile prosthesis. *BJU Int* 2010; 106: 691–4.
- Chung E, Solomon M, De Young L, Brock GB. Comparison between AMS 700™ CX and Coloplast™ Titan inflatable penile prosthesis for Peyronie's disease treatment and remodeling: clinical outcomes and patient satisfaction. *J Sex Med* 2013; 10: 2855–60.
- Habous M, Tealab A, Farag M, Soliman T, Williamson B, *et al*. Malleable penile implant is an effective therapeutic option in men with Peyronie's disease and erectile dysfunction. *Sex Med* 2018; 6: 24–9.
- Garaffa G, Minervini A, Christopher NA, Minhas S, Ralph DJ. The management of residual curvature after penile prosthesis implantation in men with Peyronie's disease. *BJU Int* 2011; 108: 1152–6.
- García-Gómez B, González-Padilla DA, Alonso-Isa M, Medina-Polo J, Romero-Otero J. Plication techniques in Peyronie's disease: new developments. *Int J Impot Res* 2020; 32: 30–6.
- Nesbit RH. Congenital curvature of the phallus: report of three cases with description of corrective operation. *J Urol* 1965; 93: 230–2.
- Essed E, Schroeder FH. New surgical treatment for Peyronie disease. *Urology* 1985; 25: 582–7.
- Gholami SS, Lue TF. Correction of penile curvature using the 16-dot plication technique: a review of 132 patients. *J Urol* 2002; 167: 2066–9.
- Yachia D. Modified corporoplasty for the treatment of penile curvature. *J Urol* 1990; 143: 80–2.
- Rolle L, Tamagnone A, Timpano M, Destefanis P, Fiori C, *et al*. The Nesbit operation for penile curvature: an easy and effective technical modification. *J Urol* 2005; 173: 171–4.
- Tausch TJ, Chung PH, Siegel JA, Gliga L, Klein AK, *et al*. Intraoperative decision-making for precise penile straightening during inflatable penile prosthesis surgery. *Urology* 2015; 86: 1048–52.
- Chung PH, Scott JF, Morey AF. High patient satisfaction of inflatable penile prosthesis insertion with synchronous penile plication for erectile dysfunction and Peyronie's disease. *J Sex Med* 2014; 11: 1593–8.
- Rahman NU, Carrion RE, Bochinski D, Lue TF. Combined penile plication surgery and insertion of penile prosthesis for severe penile curvature and erectile dysfunction. *J Urol* 2004; 171: 2346–9.
- Hudak SJ, Morey AF, Adibi M, Bagrodia A. Favorable patient reported outcomes after penile plication for wide array of peyronie disease abnormalities. *J Urol* 2013; 189: 1019–24.
- Kadioglu A, Salabaş E, Özmez A, Ural AF, Yücel ÖB, *et al*. Peyronie's disease surgery: surgical outcomes of 268 cases. *Türk J Urol* 2018; 44: 10–5.

- 48 Perito P, Wilson S. The Peyronie's plaque "scratch": an adjunct to modeling. *J Sex Med* 2013; 10: 1194–7.
- 49 Bella AJ, Beasley KA, Obied A, Brock GB. Minimally invasive intracorporeal incision of Peyronie's plaque: initial experiences with a new technique. *Urology* 2006; 68: 852–7.
- 50 Antonini G, De Berardinis E, Del Giudice F, Busseto GM, Lauretti S, *et al*. Inflatable penile prosthesis placement, scratch technique and postoperative vacuum therapy as a combined approach to definitive treatment of Peyronie's disease. *J Urol* 2018; 200: 642–7.
- 51 Garaffa G, Kuehhas FE, De Luca F, Ralph DJ. Long-term results of reconstructive surgery for Peyronie's disease. *Sex Med Rev* 2015; 3: 113–21.
- 52 Lyons MD, Carson CC 3rd, Coward RM. Special considerations for placement of an inflatable penile prosthesis for the patient with Peyronie's disease: techniques and patient preference. *Med Devices (Auckl)* 2015; 8: 331–40.
- 53 Segal RL, Cabrini MR, Bivalacqua TJ, Burnett AL. Penile straightening maneuvers employed during penile prosthesis surgery: technical options and outcomes. *Int J Impot Res* 2014; 26: 182–5.
- 54 Rigaud G, Berger RE. Corrective procedures for penile shortening due to Peyronie's disease. *J Urol* 1995; 153: 368–70.
- 55 Sansalone S, Garaffa G, Djinovic R, Egydio P, Vespasiani G, *et al*. Simultaneous penile lengthening and penile prosthesis implantation in patients with Peyronie's disease, refractory erectile dysfunction, and severe penile shortening. *J Sex Med* 2012; 9: 316–21.
- 56 Austoni E, Colombo F, Romanò AL, Guarneri A, Kartalas Goumas I, *et al*. Soft prosthesis implant and relaxing albuginea incision with saphenous grafting for surgical therapy of Peyronie's disease: a 5-year experience and long-term follow-up on 145 operated patients. *Eur Urol* 2005; 47: 223–9.
- 57 Silvani M, Pecoraro S, Zucchi A. Corporoplasty for induration penis plastica with soft axial tutors, single relaxing albuginea incision and safenous grafting. A 3-year follow up. *Arch Ital Urol Androl* 2012; 84: 84–8.
- 58 Zucchi A, Silvani M, Pecoraro S. Corporoplasty with small soft axial prostheses (VIRILIS I®) and bovine pericardial graft (HYDRIX®) in Peyronie's disease. *Asian J Androl* 2013; 15: 275–9.
- 59 Pathak AS, Chang JH, Parekh AR, Aboseif SR. Use of rectus fascia graft for corporeal reconstruction during placement of penile implant. *Urology* 2005; 65: 1198–201.
- 60 Djordjevic ML, Kojovic V. Penile prosthesis implantation and tunica albuginea incision without grafting in the treatment of Peyronie's disease with erectile dysfunction. *Asian J Androl* 2013; 15: 391–4.
- 61 Fernández-Pascual E, Gonzalez-García FJ, Rodríguez-Monsalve M, Turo J, Martínez-Ballesteros C, *et al*. Surgical technique for complex cases of Peyronie's disease with implantation of penile prosthesis, multiple corporeal incisions, and grafting with collagen fleece. *J Sex Med* 2019; 16: 323–32.
- 62 Farrell MR, Abdelsayed GA, Ziegelmann MJ, Levine LA. A comparison of hemostatic patches versus pericardium allograft for the treatment of complex Peyronie's disease with penile prosthesis and plaque incision. *Urology* 2019; 129: 113–8.
- 63 Falcone M, Preto M, Ceruti C, Timpano M, Garaffa G, *et al*. A comparative study between 2 different grafts used as patches after plaque incision and inflatable penile prosthesis implantation for end-stage Peyronie's disease. *J Sex Med* 2018; 15: 848–52.
- 64 Natali A, Olianias R, Fisch M. Penile implantation in Europe: successes and complications with 253 implants in Italy and Germany. *J Sex Med* 2008; 5: 1503–12.
- 65 Wilson SK, Mora-Estaves C, Egydio P, Ralph D, Habous M, *et al*. Glans necrosis following penile prosthesis implantation: prevention and treatment suggestions. *Urology* 2017; 107: 144–8.
- 66 Rolle L, Ceruti C, Timpano M, Sedigh O, Destefanis P, *et al*. A new, innovative, lengthening surgical procedure for Peyronie's disease by penile prosthesis implantation with double dorsal-ventral patch graft: the "sliding technique". *J Sex Med* 2012; 9: 2389–95.
- 67 Rolle L, Falcone M, Ceruti C, Timpano M, Sedigh O, *et al*. A prospective multicentric international study on the surgical outcomes and patients' satisfaction rates of the "sliding" technique for end-stage Peyronie's disease with severe shortening of the penis and erectile dysfunction. *BJU Int* 2016; 117: 814–20.
- 68 Egydio PH, Kuehhas FE, Sansalone S. Penile length and girth restoration in severe Peyronie's disease using circular and longitudinal grafting. *BJU Int* 2013; 111: 213–9.
- 69 Egydio PH, Kuehhas FE. Penile lengthening and widening without grafting according to a modified 'sliding' technique. *BJU Int* 2015; 116: 965–72.
- 70 Egydio PH, Kuehhas FE. The multiple-slit technique (MUST) for penile length and girth restoration. *J Sex Med* 2018; 15: 261–9.
- 71 Fang A, Wang R. Nondegloving technique for Peyronie's disease with penile prosthesis implantation and double dorsal-ventral patch graft. *Asian J Androl* 2018; 20: 90–2.
- 72 Clavell-Hernández J, Wang R. Penile size restoration with nondegloving approach for Peyronie's disease: initial experience. *J Sex Med* 2018; 15: 1506–13.
- 73 Akerman J, Kovac JR. Treatment of Peyronie's disease via preoperative intralesional collagenase *Clostridium histolyticum* followed by placement of an inflatable penile prosthesis: the new standard of care? *Transl Androl Urol* 2017; 6: 822–3.
- 74 Chung E, Scott S, Wang J. A state-of-art review on collagenase *Clostridium histolyticum* and Peyronie's disease: drug profile, clinical evidence and safety outcomes. *Expert Opin Biol Ther* 2020; 20: 559–64.
- 75 DeLay K, Diao L, Nguyen HM, Zurawin J, Libby R, *et al*. Successful treatment of residual curvature in Peyronie disease in men previously treated with intralesional collagenase *Clostridium histolyticum*. *Urology* 2017; 110: 110–3.
- 76 Fischer S, Diehm Y, Henzler T, Berger M, Kolbenschlager J, *et al*. Long-term effects of the collagenase of the bacterium *Clostridium histolyticum* for the treatment of capsular fibrosis after silicone implants. *Aesthetic Plast Surg* 2017; 41: 211–20.
- 77 Fischer S, Hirsch T, Diehm Y, Kiefer J, Bueno E, *et al*. The collagenase of the bacterium *Clostridium histolyticum* for the treatment of capsular fibrosis after silicone implants. *Plast Reconstr Surg* 2015; 136: 981–9.

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