

Peyronie's Disease: Surgical Management

Editors:

Jonathan Clavell-Hernández, MD, FACS

Authors:

Jonathan Clavell-Hernández, MD, FACS; Matthew J. Ziegelmann, MD

Last Updated:

Wednesday, February 15, 2023

Keywords

Peyronie's Disease, Penile Curvature, Penile Plication, Incision and Grafting, Penile prosthesis

Key Points

1. Surgery for men with Peyronie's Disease should be considered when penile curvature that limits the ability to engage in satisfactory intercourse, whose curvature has been stable (non-worsening) for 3-6 months, and who have been appropriately counseled on the risks, benefits, and alternative treatment pathways.
2. The decision to pursue surgical intervention and the specific procedure to be performed is determined by a process of shared decision making between the patient and surgeon. Prior to pursuing surgery objective assessment of deformity and subjective assessment of symptoms and degree of bother must be performed. [Figure 1]
3. Options for penile straightening surgery for men with Peyronie's Disease including penile plication, plaque incision (or partial excision) and grafting, and penile prosthesis placement with adjunctive str manuevers. [Figures 2-5]
4. A thorough discussion of the risks, benefits, and alternatives will ensure optimal outcomes. Specifically, the goal with surgery for Peyronie's Disease is to optimize sexual function, as opposed to return penis to the state it was in prior to onset of Peyronie's Disease symptoms.

1. Introduction

Peyronie's Disease (PD) is a condition characterized by acquired deformities of the penis. PD most commonly presents with uniplanar or multiplanar curvature. Other manifestations include penile pain (usually short-lived), penile shortening, narrowing or "pivot" formation along the penile shaft (referred to as "indentation" or "hourglass" deformity), and hinging or buckling of the phallus with erection.¹ Erectile and ejaculatory dysfunction are frequently seen in men with PD as well.

2. Management of PD

The goal of PD treatment is to improve penile deformity, thereby enhancing the ability to engage in satisfactory sexual intercourse while preserving other aspects of sexual function including for penile tumescence.^{2,3} Secondary goals include optimizing penile length and promoting psychological well-being. Unfortunately, there is no treatment that universally and reliably returns the penis to its baseline size and shape (prior to symptom onset).

In 2015 the AUA published guidelines regarding the diagnosis and treatment of PD in order to aid clinical decision making.⁴ A variety of medical treatment approaches including oral medications, topical and intralesional injections have been proposed, many with limited supportive evidence regarding treatment efficacy. Please see the AUA Core Curriculum Section on **Non-Surgical Treatment of Peyronie's Disease** for more information.

In the setting of medical treatment failure or in patients who desire a more rapid and definitive treatment, surgery for PD should be considered. There is no single procedure that is appropriate for all cases. Surgical decision making encompasses a variety of considerations including patient preference, penile deformity severity, baseline erectile function, and surgeon experience. Common surgical procedures include various techniques for penile plication or corporoplasty, plaque incision/excision with grafting, and penile prosthesis implantation with and without adjunct straightening procedures.^{2,7}

3. Surgery for PD

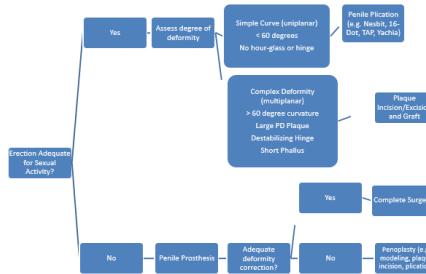


Figure 1: Algorithm for Surgical Decision Making

Surgery remains the gold standard for the correction of bothersome penile deformity in men with PD. As compared with traction and injection therapy, surgery is a more reliable approach to maximally straighten the penis. Surgery, particularly with penile straightening in the absence of concurrent penile prosthesis placement, is reserved for men in the stable phase. The true definition of the "stable phase" is not clear, it is frequently referenced by the lack of penile deformity change for at least three to six months, along with resolution of penile pain (i.e. inflammation). Commonly accepted indications for surgical treatment of include following:

- (i) **deformity that impairs satisfactory sexual relations** (severe penile bending, penile instability due to hourglass deformity, or other narrowing deformities).
- (ii) **stable deformity without pain for at least three to six months.** The distinguishing features of stable disease are deformity and plaque(s) that are unchanging and non-progressive. As discussed elsewhere, the natural history of untreated active phase PD is that of progression in approximately 40% of men within the first several months to year. However, the symptoms ultimately stabilize in the majority of men, and this is termed the "chronic" or "stable" phase. There is no agreed upon definition for the stable phase, although a period of three to six months without penile deformity change and total symptom duration of at least twelve months is suggested by the AUA PD guideline panel. It is important to note that patients with stable disease may have pain at any time, but typically pain is associated with curvature only!
- (iii) **extensive plaque calcification** and
- (iv) **failed non-surgical treatment¹⁻⁸**

In certain circumstances, patient distress or desire for immediate correction may be considered as an indication for an operation without a trial of less-invasive therapy. Ultimately, the treatment plan should be determined by a shared decision-making process between the patient and surgeon. Procedural decision-making should include considerations of the:

- nature and location of the deformity
- magnitude of penile deformity
- baseline erectile function
- penile dimensions
- surgeon's experience
- patient's preference^{3-8,9,10}

A simplified algorithm for surgical decision making is presented in Figure 1.

3.1 Penile Plication

at least

ery, an

aightening

n to the

sually
jaculatory

g capacity
ie

gents, and
Disease

of PD,⁵⁶
for PD

ghten the
out is
PD

I
e majority
'mptom
erection

I be

3.1.1 Indications

Penile plication refers to strategic suture placement on the tunica albuginea of the penis opposite that of the direction of curvature ("convex" or "longer" side). This may be accomplished with concurrent res small area of tunica albuginea at the area of plication suture placement (known as "corporoplasty"), or by plication suture placement alone. With this approach, the penile plaque on the concave (shorter) si undisturbed.

Plication surgery can be done in any patient with PD. However, it is generally accepted that the best candidates for this operations are patients who have adequate preoperative penile rigidity with or without pharmacotherapy, adequate penile length for satisfactory intercourse, simple curvature <60°, and absence of hourglass deformity or hinge.^{6-8,9,4} Patients with more severe penile curvature may also be con for penile plication with the caveat that a greater number of plication sutures may be required.¹¹ Some surgeons solely offer plication, in lieu of procedures that involve grafting, even in men with what may t considered more "complex" deformities such as multiplanar curvature.¹² Patients with borderline erectile function or multiple risk factors for ED (tobacco abuse, coronary artery disease, hypertension, dyslipidemia mellitus, etc) who desire surgical straightening but wish to forego penile prosthesis placement should be considered for penile plication even with more severe deformities given the elevated risk f postoperative erectile dysfunction with grafting procedures, as will be discussed below¹³⁻¹⁴

Historically, plication procedures were classified as "shortening procedures", as compared with incision/excision and grafting procedures which were known as "lengthening procedures".¹⁵ The loss of intrin elasticity extends well beyond the area of maximum curvature, thereby resulting in less elongation of the penis with erection.¹⁶ As such, the majority of patients with PD suffer from bothersome penile length and penile length is a concern postoperatively regardless of the surgical approach.¹⁷ With plication, the goal is to minimize perceived and actual shortening. Greater baseline penile curvature is associated v greater objective (measured) penile length loss post-operatively.¹⁸ Accurate preoperative erect penile length assessment in the setting of PD curvature is challenging, but it has been suggested that stretch penile length from pubis to corona is a reproducible and with less variability relative to other methods.¹⁹ Alternatively, the expected length loss on the long side of the penis can be estimated (albeit with que accuracy) during preoperative curvature/hemodynamics testing while the patient is erect by measuring the difference in length between the long and short side of the penis. If one considers the penis as a , regardless of the perceived and objectively measured length loss, there is undoubtedly some degree of erect penile volume loss.^{19,20} It is important to have a frank and honest discussion with patients regar perceived penile length loss, as it is a frequent cause for postoperative dissatisfaction even with extensive preoperative counseling.

3.1.2 Operative Considerations

Penile plication aims to match the length of the convex side of the tunica albuginea to the length of the concave side.¹⁵⁻²¹ In men with PD, the tunical plaque restricts expansion asymmetrically in the area o prominent fibrosis. This causes the penis to curve or exhibit other deformities as the corporal bodies are limited from full expansion/elongation. During plication the surgeon is recreating symmetric expansi corporal bodies during erection.

The Nesbit procedure was the first technique used for plication. Many variations of this have been subsequently used by reconstructive urologists, and the details contained in here are not representative o exhaustive review of the literature. A brief description of the four most common approaches is summarized (**Figures 2 - 5**).²² In brief, the Nesbit entails an elliptical excision of the tunica albuginea contralate area of maximal curvature.^{15-21,22} Alternative forms of penile plication include the Yachia (vertical incision of the tunica albuginea closed transversely, in a Heineke-Miculicz fashion, without removal of tunica albuginea),^{23,24} the 16-dot procedure (no incision but the tunica albuginea is folded on itself, or plicated, with permanent sutures using an extended Lembert-type suture following numerous dots),^{25,26} and tuni albuginea plication (TAP). In the TAP, a pair of transverse parallel incisions are made from 1–1.5 cm in length down through the external longitudinal fibers of the penile tunica albuginea without violation of internal circular fibers of the tunica. These incisions are separated by 0.5–1.0 cm and the longitudinal fibers between the two transverse incisions are removed before closing to reduce the bulk of the plicat plication is then performed with a permanent suture in a vertical mattress fashion.

Surgical approach to penile plication may utilize a midline incision (dorsal or ventral), lateral penile, or a circumcising incision. A circumcising incision may permit better exposure but carries some risk of pr edema post-operatively. A non-circumcising incision is indicated for men who are uncircumcised and do not wish to undergo circumcision. Classically, permanent, synthetic braided sutures have been pref plication.²⁷⁻²⁹ There has been interest in use of absorbable sutures as a means to reduce the possibility of granuloma formation and/or pain but peer-reviewed publications supporting this practice are scant. F can resume sexual activity approximately 4-6 weeks postoperatively.

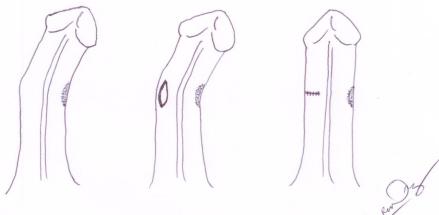


Figure 2: The Nesbit Procedure. A full-thickness longitudinal ellipsoid segment of tunica albuginea is excised on the convex side of the penis (opposite the curvature). The defect is then closed to promote penile straightening.

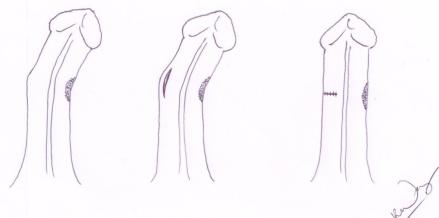


Figure 3: The Yachia Procedure. A full-thickness vertical incision is made in the tunica albuginea on the convex side of the penis (opposite the curvature). The incision is closed transversely (Heineke-Miculicz) fashion. As compared with the Nesbit procedure, there is no tissue excision.

ection of a
de is left

It
sidered
re
pidemia,
or

sic tunical
loss,
with
ed flaccid
stionable
cylinder,
ding

f the most
on of the

f an
eral to the

ca
the
ion). The

epital
erred for
patients

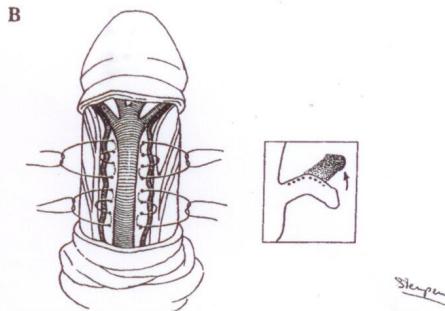
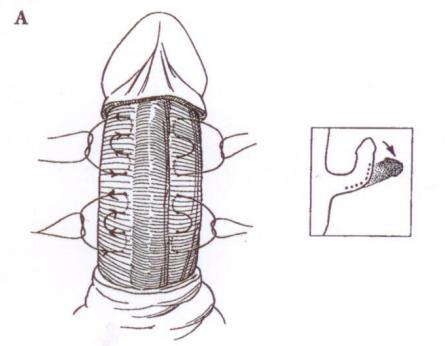


Figure 4: The 16 Dot Procedure

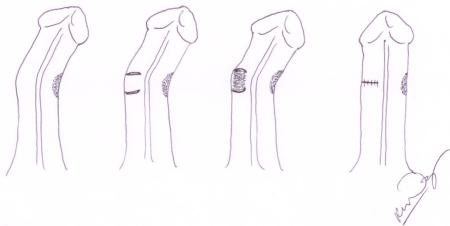


Figure 5: The Tunica Albuginea Plication (TAP)

3.1.3 Outcomes

Table 1 highlights some of the key papers in the literature representing outcomes for penile plication surgery over the last 20+ years. The success and satisfaction of penile plication for PD vary depending on technique, assessment instrument, study population, and setting.^{21-24,25-27,30-31,32-33,34} Preoperative penile length, degree, and direction of curvature deformity correlate with postoperative satisfaction.¹⁸ Outcomes including the definition of "successful" straightening vary widely in the published literature. Complete curvature correction rates range from 42-100%, and overall satisfaction ranges from 62-100%.³⁵ Primary contributing to satisfaction included penile straightening and improved sexual performance.³⁶ Dissatisfaction is generally associated with postoperative penile shortening, ED, and change of penile shape at sensation.⁶⁻³⁶

Penile plication surgeries are relatively simple for surgeons to perform given that most primarily dorsal, lateral, and dorsolateral curvatures do not require full neurovascular bundle elevation. Ventral curvatures potentially more complex, as placement of dorsal plication sutures may require resection of the midline deep dorsal penile vein and/or elevation of the neurovascular bundle to prevent iatrogenic injury to the neurovascular bundle.

3.1.4 Complications

The major complications of penile plication procedures (**Table 1**) include (i) **perceived loss of penile length due to shortening of the long side of the penis**, (ii) **unstable penis** due to persistent or exaggerated hinge or hourglass effect (in patients with preoperative indentation deformity), (iii) **persistent pain** (iv) **persistence or recurrence of penile curvature** greater than >30 degrees (8-11%), (v) **penile hematoma** 0-9%, (vi) **urethral injury** 0-1.4% (vii) **temporary or permanent sensation loss** (4-21%, may be minimized with care to avoid excessive manipulation or direct injury to the neurovascular bundle with dorsal placement), and (viii) de novo ED which is rare (0-23%), particularly with plication techniques wherein the full thickness of the tunica is not violated.^{22,37} The majority of patients note palpable suture notes, but the minority (0-21%) report significant bother related to penile pain, suture granuloma, or sensitivity changes as a result of the sutures. Bothersome suture palpability may be mitigated by inversion and burying suture knots during placement.

on
es
y factors
nd

ures are
ie

cerbated
toma
al suture
ut only
ying of the

Table 1. Outcomes for Penile Plication Procedures

Procedure	Author/Date	Surgical Outcomes (%)						Overall Satisfaction
		Complete Deformity Correction	Penile Shortening	De Novo ED	Loss of Penile Sensation	Post-operative Pain		
Nesbit	Syed et al, 2003 ²¹	62	50	12 [§]	21	NR	76	
	Cayan et al 2019 ³⁸	89.7	43.5	0.8	29.8	2.5	90.9	
Tunical albuginea plication (TAP)	Paez et al 2007 ³⁹	42	NR	61	66	28	NR	
	Taylor et al, 2008 ²⁷	93	18	10	31	NR	84	
	Seveso et al, 2018 ⁴⁰	92	100	2	8	10	77	
	Li et al, 2022 ⁴¹	90	78	NR	6	6	94	
	Reddy et al, 2020 ⁴²	98	13	NR	NR	11	NR	
Yachia Procedure	Daitch et al 1999 ⁴³	93	57	7	0	0	79	
	Rehman et al, 1997 ²⁴	73	73	23	19	NR	77	
Giammusso Procedure	Giammusso et al, 2004 ³⁰	100	67	8	0	0	83	
Lemberger Procedure	Lemberger et al 1984 ³¹	94	NR	33	5	0	78	
The 16- or 24-dot Procedure	Gholami et al, 2002 ²⁵	93	41	6	6	11	96 [#]	
	Cayan et al 2019 ³⁸	87.6	52	0.5	5.4	5.4	91.1	
Essed-Schröder Tunical Plication	Van der Horst et al, 2004 ³⁶	100	74	36	28	14	68	
	Frieddrich et al, 2000 ³³	81	19	3	7	26	81	
	Cantoro et al, 2014 ⁴⁴	91	22.5	0	8.9	NR	NR	
	Iacono et al, 2012 ⁴⁵	100	60	0	4	25	90	
Penoscrotal Plication	Dugi et al, 2010 ⁴⁶	93	0	NR	0	6	93	
	Hudak et al, 2013 ⁴⁷	NR	78	NR	NR	6	95	
Tunical Plication combined with plaque thinning with carbide burs	Ding et al, 2010 ⁴⁸	83	67	0	NR	NR	100	



ion

§ED worsened after surgery

||Persistent preoperative ED

‡-1CPC, n = 8; PD, n = 4

‡-2CPC, n = 16; PD, n = 116

¶100% satisfaction in 12 patients who had undergone failed Nesbit procedures

‡-3CPC, n = 19; PD, n = 12

‡-4CPC, n = 3; PD, n = 45

3.2. Plaque Incision/Excision and Graft

3.2.1 Indications

Plaque incision or partial excision with graft procedures are appropriate for patients with (i) **full to near full preoperative rigidity** with or without pharmacotherapy, (ii) **complex penile deformity** (i.e. curve, destabilizing indentation or hourglass resulting in hinge-effect), (iii) **large (calcified) plaques**, and (iv) **short penile length**.^{5-6,8-9}

3.2.2 Operative Considerations

Initially, surgeons believed the best approach to treat and reduce risk of recurrence of complex deformities was excision of the entire scarred/diseased tissue and coverage of the defect with a graft.⁴⁹⁻⁵⁰ However, excisional techniques demonstrated poor outcomes.⁵¹ Previous work has found that tunical defect size may be an independent risk factor for postoperative ED.³⁵⁻³⁷ This is logical as plaque excision invariably disrupts the subtunical venous trapping mechanism and may increase the risk for postoperative ED from venous leak. Therefore, modern techniques seek to minimize defects through incision or partial excision of the (the most involved area contributing to the deformity) with resultant expansion of the tunica albuginea followed by graft placement.⁵² In the subsequent text, we will most frequently make reference to plaque "incision", but the same elements hold true for partial plaque "excision" as well.

During plaque incision and grafting procedures, an incision of the plaque is made at the point of maximum curvature on the convex side of the penis to "release" the scar. This is followed by placement of a material to repair the defect. Plaque incision is sometimes referred to as a "lengthening" procedure, and in essence, by incising the scar, there is the potential to lengthen the shorter side of the penis.⁵²⁻⁵⁷ That said, subjective patient-perceived shortening is frequently reported and should be discussed with patients preoperatively. As previously discussed, there is diffuse loss of penile elasticity beyond the area of maximum curvature that contributes to diminished penile lengthening during tumescence. Some surgeons prefer partial plaque excision, particularly when severe indentation or hourglass deformity is present. Advocates note that excising the most involved area may allow for restoration of girth and improved penile stability over incision alone. To date there has not been an adequately powered head-to-head comparison of techniques.

Table 2 highlights several representative papers in the literature regarding specific graft types and associated outcomes with plaque incision (partial excision) and grafting, differentiated by graft type (i.e. **autologous grafts, allografts, xenografts, and synthetic grafts**).^{2,6} The ideal graft will have the approximate strength and elastic characteristics of normal tunica albuginea. A thin, pliable, easily sutured graft with minimal tissue reactivity and low risk of infection is ideal.⁸ No graft is universally felt to be superior, and all currently available grafts are associated with potential complications.⁵³

Autologous tissue has the advantage of minimal immunogenicity, cost, and beneficial tissue properties. Donor site complications and the extra surgical time required to harvest the graft are important limitations of autologous grafts (saphenous vein, temporalis fascia, fascia lata, tunica albuginea).^{8,21,22}

All contemporary allografts and xenografts used in PD surgery are processed sheets of collagen matrix. Examples include **processed pericardium** and **small intestinal submucosa (SIS)**. These grafts are commercially available and easy to use.³ Synthetic grafts (Dacron®, GoreTex®) are not recommended for management of PD due to the risks of local inflammation, infection and intense fibrosis.⁵⁴ The Tact® collagen-fleece hemostatic patch has recently gained traction among some PD surgeons because of its ease of use (no need to suture the graft in place), who have reported favorable outcomes and low rates of complications.^{55-56,57} Tissue-engineered or stem cell seeded grafts have been tested in animal models, but human data on this approach are currently lacking.⁵⁸⁻⁵⁹

Some experts advocate for application of external penile traction therapy in the postoperative period to minimize loss of length. A retrospective study found that perceived penile length loss was minimal in those utilizing traction therapy, although dissatisfaction with penile length overall remained high at 46% of surveyed patients.⁶⁰ Absence of randomization makes interpreting these data difficult. If traction therapy is utilized, it should be initiated only when the skin incision has healed and the patient can tolerate stretching forces applied to the penis.

Table 2: Graft Materials Used In Peyronie's Disease
Reconstructive Surgery And Surgical Outcomes

Graft Type	Type of Tissues	Author Date	Patients (N)	Mean Follow-up (months)	Surgical Outcomes (%)					
					Straightening	Shortening	Postoperative ED	Sensory change	Pain	Satis
Autografts	Rectus sheath	Craatz et al, 2006 ⁶¹	12	4 to 10 (range)	100.0	NR	0.0	NR	NR	58.3
	Tunica Vaginalis	O'Donnell et al, 1992 ⁶²	25	42.2	88.0	96.0	68.0	16.0	NR	NR
	Dermal graft	Goyal et al, 2008 ⁶³	11	6 to 24 (range)	81.8	NR	9.1	18.2	0.0	81.8
		Chung et al, 2010 ⁵³	6	101.8	50.0	17.0	Significantly lower than preoperative ED ($P<0.01$)	13.0	NR	35.0
	Dermal flap	Simonato et al, 2010 ⁶⁴	22	95.0	63.6	NR	31.8	NR	NR	40.9
	Buccal mucosa	Cormio et al, 2009 ⁶⁵	15	13.1	100.0	0.0	0.0	0.0	NR	93.1
		Ainayev et al, 2021 ⁶⁶	20	24	90	NR	55 (mild ED only based on IIEF)	0	0	90
		Salem et al, 2014 ⁶⁷	17	9-18	88.2	NR	5.8	NR	NR	94
		Fabiani et al, 2016 ⁶⁸	17	22.5	100	NR	NR	NR	NR	94
	Fascia lata graft	Kargi et al, 2004 ⁶⁹	12	10	100.0	0.0	0.0	NR	NR	100.0
	Venous graft	El-Sakka et al, 1998 ⁷⁰	112	18	96.0	17.0	12.0	10.0	6.2	92.0
		Wimpissinger et al, 2016 ⁷¹	30	156	86-7	43.3	36.7	20	NR	73
		Kadioglu et al, 2018 ⁷²	144	51.1	100.0	NR	33.3	NR	NR	NR
Allografts	Tutoplast® human pericardium	Chun et al, 2001 ⁷³	9	6	55.5	NR	11.0	0.0	NR	88.9
		Taylor et al, 2008 ²⁷	81	58	91.0 [‡]	33.0	32.0	31.0	NR	75.0
		Chung et al, 2010 ⁵³	23	79.2	87.0	17.0	Significantly lower than preoperative ED ($P<0.01$)	13.0	NR	35.0
		Levine et al, 2003 ⁷⁴	40	22.0	98.0	33.0	30.0 [†]	2.0	NR	NR

	Tutoplast® fascia lata graft	Kalsi et al, 2006 ⁷⁵	14	31	79.0	28.6	7.1	7.1	NR	93.0
Xenografts	Porcine small intestinal submucosa	Sayedahmed, et al 2017 ⁷⁶	43	33.0	74.4	27.9	7.0	9.3	7.0	86.0
		Kovac et al, 2007 ⁷⁷	13	7.8	76.9	46.0	23.0	23.0	NR	84.6
		Chung et al, 2010 ⁵³	17	75.5	76.6	29.0	Significantly lower than preoperative ED ($P<0.01$)	13.0	NR	35.0
		Knoll et al , 2007 ⁷⁸	162	38	91.0	5.0	21.0	17.0	0.0	NR
		Lee et al, 2008 ⁷⁹	13	14 (median)	100.0 ^{\$}	NR	54.0	NR	NR	NR
		Rosenhammer et al 2018 ⁸⁰	43	31	86	28	7	9	NR	86
		Breyer et al, 2007 ⁸¹	19	15	63.0	63.0	53.0	NR	26.0	score out of
Bovine pericardium graft	Bovine pericardium graft	Egydio et al, 2002 ⁸²	33	19.5	87.9	NR	0.0	NR	NR	NR
		Ofero et al, 2016 ⁸³	41	14	80.5	No Difference	NR	4.8	NR	85.4
		Fiorillo et al, 2021 ⁸⁴	34	Median 32 months (range 18-51)	76.5	79.4	23.5	38.2	17.6	88.2
TachoSil®†	Porcine dermal graft	Fiorillo et al, 2021 ⁸⁴	19	Median 85 months (range 72-95)	73.7	78.9	36.8	57.9	5.3	78.9
		Hortsman et al, 2011 ⁸⁵	43	63.0	41.0	40.0	9.0	7.0 (severe) 16.0 (moderate)	7.0	20.0
		Hatzichristodoulou et al, 2017 ⁸⁶	319	47.2	93.7	NR	15.7	6.0	NR	87.8
		Fernandez-Pascual, 2020 ⁵⁷	52	5.2	88	64.3	14	36	2.4	78.5
Synthetic grafts	Polyethylene terephthalate mesh reinforced silicone sheet patch graft	Hatzichristodoulou et al, 2021 ⁸⁷	367	47.2	91.2	NR	15.7	6.0	NR	87.9 (patient 84.3 (partner
		Licht et al, 1997 ⁸⁸	28	22	61.0	30.0	18.0	14.0	NR	30.0

ED, erectile dysfunction
NR, not reported.

* Tutoplast® is a commercially available, modified human fascia lata that can act as a scaffold to allow tunical regeneration (Tutoplast®, Mentor Corp, Santa Barbara, CA, USA).³⁵

[#]Defined straight as residual curvature of <30°.

[§]Defined straight as residual curvature of 0° to 15°.

[†]TachoSil® (surgical patch) combines the bioactive mechanism of action of human coagulation factors, fibrinogen and thrombin, with the mechanical support of a [equine] collagen patch (Takeda Pharmaceuticals International GmbH, Zurich, Switzerland).⁶⁵

3.2.3 Outcomes

Success and satisfaction rates of incision/excision with grafts are listed in **Table 2**.^{53-64,67-68,74-83,85-89} Complete deformity correction rates range from 50-100%, and the satisfaction rates are highly variable, ranging from 35-94%.⁷⁹⁻⁸⁸ The nature of the deformity, physician's experience, and patient's preferences may factor into graft material selection.³

3.2.4 Complications

The most concerning adverse event after incision/excision with graft procedures is post-operative ED. In the few single-center surgical outcome reviews with 5 or more years of follow up, ED has been reported in up to 30% of patients.⁹⁰ **Preoperative erectile status is the most important predictor of postoperative ED.**¹³⁻⁹¹ Additional factors associated with greater risk of ED include evidence of baseline corpora veno-occlusive dysfunction (resistive index < 0.80 on duplex ultrasound), ventrally located curvature, larger graft size,¹⁴ and severity of curvature (which may correspond to graft size).³⁷ Some risks are graft specific. For example, autologous grafts are associated with harvest site comorbidities.³⁷ Synthetic grafts are often associated with increased risk of infection and fibrosis resulting from significant inflammation around the graft site. Contracture with recurrent curvature has been reported in up to 75% of cases in some studies.³⁷ Diminished sensation from disruption of sensory nerves during dorsal graft placement up to 31% of cases.²⁷ However, a recent study showed sensation loss decreases in frequency and severity with time with only rare cases occurring 12 months after surgery.⁹² Other complications include hematuria and penile shortening which may result from graft contraction. Given these potential adverse events, it is important to counsel patients regarding these and other risks with surgery and set appropriate expectations prior to surgery. Ultimately, the goal with PD surgery is to correct/improve penile curvature as opposed to returning the penis to the state prior to onset of PD. Most patients will have mild residual curvature or indentation deformities after grafting surgery, but they are better able to engage in satisfactory sexual intercourse.

3.3. Penile Prosthesis Placement

3.3.1 Indications

Penile prosthesis implantation is indicated when patients have PD and concurrent ED refractory to medical therapy or in men with severe, complex deformity (significant curvature or indentation/hourglass deformity) and risk factors for ED.^{5-6,93-94,95}

For more information on penile prosthesis placement, please also see the AUA Core Curriculum Section on **Erectile Dysfunction: Surgical Management**.

3.3.2 Operative Considerations

3.3.2.a Device Selection

Multi-component inflatable penile prosthesis models are often recommended over semi-rigid/malleable rods.⁴ Suggested benefits with the inflatable models include greater deformity correction due to the inflation pressures applied within the corpora, greater concealment when the device is deflated, greater girth enhancement, and higher degrees of partner satisfaction.⁹⁶⁻⁹⁷ Both the Boston Scientific/American Medical Systems CX 700 and Coloplast Titan 3-piece inflatable models are excellent options, and a study by Chung et al found no significant differences in device outcomes between these models.⁹⁸ In contrast, the Scientific/American Medical Systems LGX, which has the ability for transverse and longitudinal expansion, is not recommended for patients with PD due to the potential to exacerbate penile deformities.⁹⁹ It should be noted that the purported benefits of inflatable penile prosthesis models over semi-rigid/malleable are based in part on surgeon anecdote and limited literature with significant limitations. A 2018 Habous et al from Saudi Arabia compared outcomes in a cohort of 166 patients who underwent prosthesis placement in the setting of PD, including 136 (82%) who received a malleable prosthesis.¹⁰⁰ Adjunct maneuvers were required in roughly 40% of the cohort. With a mean follow-up of nearly two years, the authors did not find any difference in the rate of penile straightening or patient satisfaction based on the prosthesis that was placed (i.e. inflatable versus malleable). Given the high cost of inflatable models, semi-malleable prostheses may offer some advantages, particularly in regions without consistent insurance coverage for penile prosthesis placement.¹⁰¹⁻¹⁰⁰⁻¹⁰²

3.3.2.b Intraoperative factors and adjunct straightening maneuvers

Penile prosthesis placement in PD patients may be complicated by presence of corporal fibrosis or tunical plaque. This can make dilation of the corpora difficult and/or increase the risk of corporal perforation. In conjunction with placement of the prosthesis, the surgeon may opt to surgically straighten the penis with modeling, plication, or incision/grafting.⁴ **This is recommended when residual curvature exceeds 20 degrees after penile prosthesis implantation.**⁹ It is important to discuss the concept of penile straightness with the patient prior to surgery. If a patient is satisfied with < 20 degrees of curvature, prosthesis placement may be all that is necessary for mild/moderate severity PD. In contrast, if the patient desires to be as close as possible to "arrow straight" upon leaving the operating room, then additional interventions are necessary.

Manual modeling (bending the penis opposite in the direction away from the plaque with the implant partially inflated) may further reduce curvature. When performing penile modeling it is important to inflate the device and place manufacturer approved rubber-shod clamps on the tubing from the pump to the cylinders to limit the risk of pressure damage to the pump. Risks of penile modeling include the possibility of migration and urethral perforation, which occurred in approximately 3% in the original series by Wilson and Delk.¹⁰³⁻¹⁰⁴ A more recent series of 80 patients from Lucas et al found that modeling reduced curvature from a mean 48 degree pre-modeling to 11 degrees post-modeling.¹⁰⁵ There were no intraoperative or postoperative complications identified.

When the post-modeling residual curve is still greater than 20°, other options for intraoperative straightening include **plication of the convex side**,³⁴ or performing a **plaque-releasing incision without or on the graft** on the convex side (typically utilized when the defect is >2.0 cm in maximum dimension).⁶³⁻⁹⁴ Grafting over a penile prosthesis is an option for men with severe PD or in those who are opposed to penile modeling due to concerns regarding further length loss. In these circumstances, the tunica albuginea is exposed at the point of maximum curvature. For dorsal and lateral curvature, this requires full or partial neurovascular bundle mobilization. For ventral curvature, this requires urethral mobilization. An incision is then made over the plaque and a grafting material is subsequently placed. Historically, multiple autogenous or off the shelf grafts were used, similar to those used for incision or partial plaque excision and grafting without a prosthesis (see **Table 2**). Several recent reports suggest that hemostatic patches such as Evarrest (Johnson and Johnson; New Brunswick, NJ, USA) following IPP placement and plaque excision.¹⁰⁶⁻¹⁰⁷⁻⁵⁶ The proposed benefit of using these novel grafting materials is the lack of need for suture or graft material in the setting of a penile prosthesis. This theoretically prevents inadvertent device damage and decreases operative time.

The scratch technique, popularized by Antonini and Perito, is another option with particular utility in those patients undergoing penile prosthesis placement via an infrapubic approach.¹⁰⁸⁻¹⁰⁹⁻¹¹⁰ This involves a nasal speculum through the corporal body which is used to stretch or "fracture" the plaque. A curved 12-blade scalpel is then used to internally scratch the PD plaque before the prosthesis is placed.¹⁰⁹ In a prospective study involving 145 patients who underwent penile prosthesis and the scratch technique, penile curvature was assessed before and immediately postoperative.¹¹⁰ The mean (+/- SD) curvature significantly reduced immediately after the surgery regardless of plaque location from a preoperative curve of 65.8 +/- 10.4 degrees to an immediate postoperative curve of 19.8 +/- 5.1 degrees. Patients were instructed to perform twice daily vacuum erection device therapy for an extended 24-week period, starting two weeks postoperatively. At one year follow-up, the mean curvature had further decreased to 10 degrees.

To address PD with penile shortening, an innovative surgical procedure involving penile prosthesis implantation with double dorsal-ventral patch graft – "sliding technique" was proposed. This has been suggested with different variations on surgical technique and without the use of a graft.¹¹¹⁻¹¹²⁻¹¹³ The authors of one series reported on 143 patients (53.8% patients with PD) who underwent this procedure with a mean penile length increase. The lengthening effect with sliding technique was confirmed by a multicenter study in which 28 patients with PD were treated with penile prosthesis and sliding penile lengthening. The mean follow-up was 37 months and the mean penile lengthening was 3.2 cm.¹¹⁴ Size restoration procedures such as the sliding technique in conjunction with penile degloving have been reported to carry increased risk of glans ischemia.¹¹⁵ Proposed risk factors for glans ischemia at the time of penile prosthesis placement include cardiovascular disease, diabetes, current tobacco use, radiation therapy, use of occlusive elastic bandage postoperatively, coincident urethral injury intraoperatively, and a subcoronal/circumcising incision. To avoid this risk, some authors have proposed the use of a non-degloving approach to decrease the risk of glans necrosis!¹¹⁶ Given the increased risk of complications, the sliding-technique procedure should only be performed by experienced surgeons. Large series and long-term follow-up are needed to fully establish the efficacy and the safety of this procedure.

3.3.3 Outcomes

Penile prosthesis implantation provides excellent treatment for concurrent PD and ED simultaneously in one surgical setting. Complete deformity correction rates with penile prosthesis implantation range from 84-100% (**Table 3**).^{93-94,108-117-118-119-120-121-122} Satisfaction rates for penile prosthesis implantation in the general population range from 33.3-100%.⁹⁰⁻¹²¹ Reported satisfaction with implants in men with PD is somewhat lower than in non-PD patients, although this is somewhat controversial and overall satisfaction rates remain extremely high regardless.¹¹⁹⁻¹⁰¹⁻¹²³⁻¹⁰⁰

Table 3: Penile Prosthesis Implantation

Procedure	Author/Date	Patients (N)	Mean Follow-up (months)	Surgical Outcomes (%)						
				Straightening	Shortening	Postoperative ED	Sensory change	Pain	Satisfaction	
Inflatable Penile Prosthetic Implantation	Levine et al, 2010 ⁹³	90	49.0	4.0	3.0	NR	2.0	NR	84.0	
	Levine et al, 2000 ⁹⁴	46	39.0	100.0	7.0	0.0	9.0	NR	NR	
Soft, Silicon, Axially Resistant, Prosthetic Cylinders	Austoni et al, 2005 ¹¹⁸	80	113.0	100.0	NR	0.0	5.0	7.5	95.0	
Silicon Soft Dynamic Antieextrusion Prosthetic Implantation	Grasso et al, 2008 ¹¹⁷	12	72.0	100.0	NR	100.0	NR	NR	91.0	
Transcorporeal Incision (TCI)	Shaeer et al, 2010 ¹⁰⁸	16	14.0	100.0	NR	100.0	0.0	NR	100.0	
Inflatable Prosthesis	Chung et al, 2013 ¹¹⁹	138	45.6	92	62	NR	NR	NR	79	
Malleable and Inflatable Prosthesis	Djordjevic et al, 2013 ¹²⁰	62	35	95	NR	NR	23/62	NR	94	
Inflatable Prosthesis	Chung et al, 2014 ¹²¹	15	15.4	93.3	73	NR	NR	0	33.3%	
Malleable Prosthesis	Yavuz et al, 2015 ¹²²	59	9.7	100	4.5	NR	0	NR	91.5	

ED, erectile dysfunction

NR, not reported

3.3.4 Complications

As in any patient with penile prosthesis implantation, patients with PD receiving a penile implant are at risk for prosthesis infection, mechanical failure, diminished sensitivity, and device operation difficulties. Possibility of dissatisfaction with implant length and persistent curvature should be discussed with patients prior to surgery. See the AUA Core Curriculum Section on [Erectile Dysfunction: Surgical Management](#) for more information on ED surgery.

4. Costs

There are no robust, peer-reviewed, published data on the cost of surgical management for PD in the United States. The absence of such data is likely driven by the absence of a unified therapeutic approach that could be measured and studied. Cost differences in graft materials may impact institution-specific surgical approaches for the treatment of PD.

5. Clinical Care Pathway

Patients with PD should be evaluated for chronicity, pain with erection, degree of impairment related to penile deformity, and maximal rigidity of penile erection (i.e. for ED). The most reliable mean to assess curvature and deformity is in-office injection of erectile agents with or without penile duplex Doppler ultrasound to induce penile tumescence. Please see the section on Erectile Dysfunction: Patient Evaluation for more detailed information on penile ultrasound technique and results interpretation. Home photography of the erect penis may be useful in some cases, but definitive deformity assessment should be based on variations in the angle of the photograph and inability to assess erection firmness. It is important to recognize that degree of deformity may not be commensurate with psychological distress and/or degree of interference with sexual enjoyment.

Medical and surgical management should be discussed and the patient allowed to make a determination of therapeutic course based on his particular condition and circumstances. Men able to engage in safe intercourse with or without erectile agents and/or vacuum erectile device and without pain for the patient or his partner may be best served to avoid surgical intervention and simply pursue observation. In contrast, men who failed non-surgical therapy and are unable to engage in satisfactory sexual interactions due to PD +/- ED are more likely to benefit from surgical treatment.

To date, there is limited data with regard to patient demographics and the decision to pursue surgery. Bole et al found that nearly four out of five men who presented for initial PD evaluation stated they were willing to consider surgical intervention if necessary.²⁴ On multivariable analysis, younger age at presentation, history of mood disorder, perceived penile shortening, and greater mean penile curvature were associated with a higher likelihood of willingness to consider surgery. Information regarding PD treatment outcomes and race or ethnicity is even more limited, likely because most studies fail to report on race or ethnicity or include a predominantly Caucasian population. For example, only 3% of patients in the Investigation for Maximal Peyronie's reduction Efficacy and Safety Studies (IMPRESS I/II) that evaluated outcomes in men undergoing intralesion Collagenase Clostridium histolyticum were African American. This may be in part due to suggested racial or ethnicity variations in PD prevalence (PD is purportedly more prevalent in patients of European descent), but may also be the result of differences in access to care and other factors that inadvertently impact the inclusion of non-white patients in study protocols.

6. Post-Op Care Pathway

The post-op pathway is as important as the surgery to minimize any complications and to obtain the best outcomes. After penile straightening without a prosthesis, patients are instructed to remove the dressing to start taking showers 2-3 days after the surgery. They should ambulate as tolerated and resume light duty 1-2 weeks after the surgery. However, they should avoid strenuous activities, such as heavy lifting (more than 10 pounds), long distance driving, or mowing the lawn for first few weeks. They should be given detailed information to contact physicians or go to emergency room if they develop a fever, severe penile or scrotal pain and swelling, or bloody/pus drainage from the incision. There is no consensus or robust evidence to recommend antibiotics after PD surgery. However, some experts will give 5-7 days antibiotic coverage for gram positive and negative bacteria for patients who are diabetic or received graft and/or IPP. Most experts recommend avoiding sexual activity for at least 4 weeks after plication and 6 weeks after grafting procedures. There is no standardized penile rehabilitation protocol after PD surgery; massage and stretching of the penis after edema has subsided and pain decreases is recommended by some surgeons. Additional options utilized by some surgeons include routinely dosed erectile therapy (eg phosphodiesterase type 5 inhibitors) and/or external penile traction therapy to minimize length loss and potential curvature. Traction therapy should only be utilized when the skin incision is healed and the patient can tolerate stretching forces applied to the penis. In the setting of IPP placement, daily inflation starting 6 weeks after surgery may improve length outcomes.²⁷

7. Other Resources

Video Journal of Prosthetic Urology

Videos

Penile Plication Without Degloving for Repair of Biplanar Deformity due to Peyronie's disease

SURGICAL TREATMENT OF PEYRONIE'S DISEASE BY INCISION AND GRAFTING

SURGICAL TREATMENT OF PEYRONIE'S DISEASE BY INCISION AND GRAFTING

MUST:IPP AUA CC

Presentations

Peyronie's Disease: Surgical Treatment Presentation 1

References

[†] Ralph D, Gonzalez-Cadavid N, Mirone V et al. The management of Peyronie's disease: evidence-based 2010 guidelines. J Sex Med 2010; 7: 2359-74

- 1 This article proposed the evidence-based guidelines for PD and discussed the patient evaluation, non-surgical and surgical treatment. Detailed indication for surgery, surgery types, post-operative care and rehabilitation were given by group of international experts.
- 2 Kadioglu A, Akman T, Sanli O, Gurkan L, Cakan M, Celik M. Surgical treatment of Peyronie's disease: a critical analysis. Eur Urol 2006; 50: 235-48
- 3 Kumar R, Nehra A. Surgical and minimally invasive treatments for Peyronie's disease. Curr Opin Urol 2009; 19: 589-94
- 4 ☆ Nehra A, Alterowitz R, Culkin DJ, Faraday MM, Hakim LS, Heidelbaugh JJ, Khera M, Kirkby E, McVary KT, Miner MM, Nelson CJ, Sadeghi-Nejad H, Seftel AD, Shindel AW, Burnett AL. Peyronie's Disease: AUA Guideline. J 2015, Vol 194, Pages 745-753
- 5 Gur S, Limin M, Hellstrom WJ. Current status and new developments in Peyronie's disease: medical, minimally invasive and surgical treatment options. Expert Opin Pharmacother 2011; 12: 931-44
- 6 Kendirci M, Hellstrom WJ. Critical analysis of surgery for Peyronie's disease. Curr Opin Urol 2004; 14: 381-8
- 7 Cappoccia E, Levine LA. Contemporary Review of Peyronie's Disease Treatment. Curr Urol Rep 2018; 19:51.
- 8 Kadioglu A, Kucukdurmaz F, Sanli O. Current status of the surgical management of Peyronie's disease. Nat Rev Urol 2011; 8: 95-106
- 9 ☆ Levine LA, Lenting EL. A surgical algorithm for the treatment of Peyronie's disease. J Urol 1997; 158: 2149-52
- 10 Tornehl CK, Carson CC. Surgical alternatives for treating Peyronie's disease. BJU Int 2004; 94: 774-83
- 11 Reddy RS, McKibben MJ, Fuchs JS, Shakir N, Scott J, Morey AF. Plication for Severe Peyronie's Deformities Has Similar Long-Term Outcomes to Milder Cases. J Sex Med. 2018;15(10):1498-505.
- 12 Adibi M, Hudak SJ, Morey AF. Penile plication without degloving enables effective correction of complex Peyronie's deformities. Urology. 2012;79(4):831-835. doi:10.1016/j.urology.2011.12.036
- 13 Taylor FL, Abern MR, Levine LA. Predicting erectile dysfunction following surgical correction of Peyronie's disease without inflatable penile prosthesis placement: vascular assessment and preoperative risk factors. J Sex Med 2012; 9:296-301

- 14 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(7):2031-2037. doi:10.1111/j.1743-6109.2011.02299.x
- 15 Levine LA, Larsen SM. Surgery for Peyronie's disease. *Asian J Androl*. 2013;15(1):27-34.
- 16 Levine LA, Larsen S. Diagnosis and management of Peyronie disease. In: Wein AJ, Kavoussi LR, Partin AW, Peters CA, eds. *Campbell-Walsh Urology*. 11th ed. Philadelphia, PA: Elsevier; 2016:chap 31.
- 17 Goldstein I, Gelbard MK, Lipshultz LI. Clinical Significance of Shortened Penile Length and Alterations in Penile Length Following Treatment for Peyronie's Disease. *Sex Med Rev*. 2022;10(3):409-420. doi:10.1016/j.jsxmr.2021.12.010
- 18 ☆ Greenfield JM, Lucas S, Levine LA. Factors affecting the loss of length associated with tunica albuginea plication for correction of penile curvature. *J Urol* 2006; 175: 238-41
- 19 Ziegelmann MJ, Trost LW, Russo GI, Levine LA. Peyronie's Disease Intervention Studies: An Exploration of Modern-Era Challenges in Study Design and Evaluating Treatment Outcomes. *J Sex Med*. 2020;17(3):364-377. doi:10.1016/j.jsxm.2019.11.271
- 20 Davoudzadeh EP, Davoudzadeh NP, Margolin E, Stahl PJ, Stember DS. Penile Length: Measurement Technique and Applications. *Sex Med Rev*. 2018;6(2):261-271. doi:10.1016/j.jsxmr.2017.10.002
- 21 Syed AH, Abbasi Z, Hargreave TB. Nesbit procedure for disabling Peyronie's curvature: a median follow-up of 84 months. *Urology* 2003; 61: 999-1003
- 22 Pendleton CM, Wang R. Peyronie's disease: current therapy. *Transl Androl Urol* 2013; 2: 15-23
- 23 ☆ Yachia D. Modified corporoplasty for the treatment of penile curvature. *J Urol* 1990; 143: 80-2
- 24 ☆ Rehman J, Benet A, Minsky LS, Melman A. Results of surgical treatment for abnormal penile curvature: Peyronie's disease and congenital deviation by modified Nesbit plication (tunical shaving and plication). *J Urol* 1997; 158: 1288-91
- 25 ☆ 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
- 26 Odisho AY, Hampson LA, Lue TF. Innovative surgical techniques for managing Peyronie's disease: a video presentation. *Transl Androl Urol* 2013; 2:312-5.
- 27 Taylor FL, Levine LA. Surgical correction of Peyronie's disease via tunica albuginea plication or partial plaque excision with pericardial graft: long-term follow up. *J Sex Med* 2008; 5: 2221-8
- 28 ☆ Gholami J Urol. 2002 May;167(5):2066-9.
- 29 Taylor J Sex Med. 2008 Sep;5(9):2221-8
- 30 ☆ Giannusso B, Burrello M, Branchina A, Nicolosi F, Motta M. Modified corporoplasty for ventral penile curvature: description of the technique and initial results. *J Urol* 2004; 171: 1209-11
- 31 ☆ Lemberger RJ, Bishop MC, Bates CP. Nesbit's operation for Peyronie's disease. *Br J Urol* 1984; 56: 721-3
- 32 Essed E, Schroeder FH. New surgical treatment for Peyronie disease. *Urology* 1985; 25: 582-7
- 33 Friedrich MG, Evans D, Noldus J, Huland H. The correction of penile curvature with the Essed-Schroder technique: a long-term follow-up assessing functional aspects and quality of life. *BJU Int* 2000; 86: 1034-8
- 34 ☆ Hudak SJ, Morey AF, Adibi M, Bagrodia AB. Favorable patient reported outcomes following penile plication for wide array of Peyronie's deformities. *J Urol* 2013; 189:1019 – 24
- 35 Kozacioglu Z, Degirmenci T, Gunlusoy B, Kara C, Arslan M, Ceylan Y, et al. Effect of tunical defect size after Peyronie's plaque excision on postoperative erectile function: do centimeters matter? *Urology*. 2012;80(5):1051-5.
- 36 Van Der Horst C, Martinez Portillo FJ, Seif C, Alken P, Juenemann KP. Treatment of penile curvature with Essed-Schroder tunical plication: aspects of quality of life from the patients' perspective. *BJU Int* 2004; 93: 105-8
- † Levine LA, Larsen SM . Surgery for Peyronie's disease. *Asian J Androl* 2013; 15, 27-34
- 37 This article focused on surgical treatment of PD and stated that the surgery remains the gold standard treatment option, offering the most rapid and reliable treatment which will be the focus of this article. The authors reviewed the preoperative evaluation, surgical algorithm, graft materials and postoperative management of PD. They also summarized the outcomes for each surgical procedures.
- 38 Cayan S, Ramazan A, Efesoy O, Kocamanoglu F, Akbay E, Yaman O. Comparison of Patient's Satisfaction and Long-term Results of 2 Penile Plication Techniques: Lessons learned from 387 Patients with Penile Curvature. *Urologia Internationalis* 2019;129: 106-112.
- 39 Paez A, Mejias J, Vallejo J, Romero I, De CM, Gimeno F. Long-term patient satisfaction after surgical correction of penile curvature via tunical plication. *International Brazilian Journal of Urology* 2007; 33: 502-7
- 40 Seveso M, Melegari S, De Francesco O, Macchi A, Romero Otero J, Taverna G, Bozzini G. Surgical correction of Peyronie's disease via tunica albuginea plication: long-term follow-up. *Andrology* 2018;6: 47-52.
- 41 Li WJ, Bao JW, Guo JH, Zheng DC, Xie MK, Wang Z. Effects of plication procedures in special cases of Peyronie's disease: a single-center retrospective study of 72 patients. *Asian J Androl*. 2022;24(3):294-298. doi:10.4103/aja2020-1034
- 42 Reddy RS, Yi YA, Fuentes J, Bergeson RL, Davenport MT, Morey AF. Preventing the need for revision surgery after penile plication reconstruction of Peyronie's deformities. *Transl Androl Urol*. 2020;9(1):82-86. doi:10.21037/tau.2020.1034
- 43 ☆ Daitch JA, Angermeier KW, Montague DK. Modified corporoplasty for penile curvature: long-term results and patient satisfaction. *J Urol* 1999; 162: 2006-9
- 44 Cantoro U, Polito M, Catanzariti F, Montesi L, Lacetera V, Muzzonigro G. Penile plication for Peyronie's disease: our results with mean follow-up of 103 months on 89 patients. *Int J Impot Res* 2014; 26: 156-9.
- 45 Iacono F, Prezioso D, Ruffo A, Illiano E, Romeo G, Amato B. Tunical plication in the management of penile curvature due La Peyronie's disease. Our experience on 47 cases. *BMC Surg* 2012; 12 suppl 1: S25.
- 46 Dugi DDI, Morey AF. Penoscrotal plication as a uniform approach to reconstruction of penile curvature. *BJU Int* 2010; 105: 1440-4
- 47 ☆ Hudak SJ, Morey AF, Adibi M, Bagrosia A. Favorable patient reported outcomes after penile plication for wide array of Peyronie's disease abnormalities. *J Urol* 2013; 189: 1019-24.
- 48 Ding S, Lu J, Zhang H, Wei L, Ding K. A novel modification of tunical plication by plaque thinning: long-term results in treating penile curvature of Peyronie's disease. *Int Urol Nephrol* 2010; 42: 597-602
- 49 Devine CJ Jr, Horton CE. Surgical treatment of Peyronie's disease with a dermal graft. *J Urol* 1974;111: 44-49.
- 50 Lowsley OS, Boyce WH. Further experiences with an operation for the cure of Peyronie's Disease. *J Urol* 1950;63: 888-899.
- 51 Dalkin BL, Carter MF. Venogenic impotence following dermal graft repair for Peyronie's disease. *J Urol* 1991;146: 849-851.
- 52 ☆ Gelbard MK, Hayden B. Expanding contractures of the tunica albuginea due to Peyronie's disease with temporalis fascia free grafts. *J Urol* 1991; 145: 772-6
- 53 Chung E, Clendinning E, Lessard L, Brock G. Five-year follow-up of Peyronie's graft surgery: outcomes and patient satisfaction. *J Sex Med* 2010; 8: 594-600
- 54 ☆ Brannigan RE, Kim ED, Oyasu R, McVary KT. Comparison of tunica albuginea substitutes for the treatment of Peyronie's disease. *J Urol* 1998; 159: 1064-8

- 55 Rosenhammer B, Sayedahmed K, Fritsche HM, Burger M, Kübler H, Hatzichristodoulou G. Long-term outcome after grafting with small intestinal submucosa and collagen fleece in patients with Peyronie's disease: a matched pair a Int J Impot Res. 2019;31(4):256-62.
- 56 Hatzichristodoulou G. Evolution of the surgical sealing patch TachoSil® in Peyronie's disease reconstructive surgery: technique and contemporary literature review. World J Urol. 2020;38(2):315-21.
- 57 Fernández-Pascual E, Manfredi C, Torremadé J, et al. Multicenter Prospective Study of Grafting With Collagen Fleece TachoSil in Patients With Peyronie's Disease. J Sex Med. 2020;17(11):2279-2286. doi:10.1016/j.jsxm.2020.07.1
- 58 Ferretti L, Giuliani M, Bessede T et al. Tissue engineering for penile surgery: comparative study of noncellular and cell-seeded synthetic grafts for tunica albuginea replacement. J Sex Med 2012; 9: 625-31
- 59 Ma L, Yang Y, Sikka SC et al. Adipose tissue-derived stem cell-seeded small intestinal submucosa for tunica albuginea grafting and reconstruction. Proc Natl Acad Sci U S A 2012; 109: 2090-5
- 60 Rybak J, Papagiannopoulos D, and Levine L. A retrospective comparative study of traction therapy vs. no traction following tunica albuginea plication or partial excision and grafting for Peyronie's disease: measured lengths and patient perceptions. J Sex Med 2012; 9: 2396-403
- 61 Craatz S, Spanel-Borowski K, Begemann JF, Olianas R, Fisch M, Hohenfellner R. The dorsal lamina of the rectus sheath: a suitable grafting material for the penile tunica albuginea in Peyronie's disease? BJU Int 2006; 97: 134-7
- 62 ☆ O'Donnell PD. Results of surgical management of Peyronie's disease. J Urol 1992; 148: 1184-7
- 63 Goyal NK, Kumar A, Das SK et al. Experience with plaque excision and dermal grafting in the surgical treatment of Peyronie's disease. Singapore Medical Journal 2008; 49: 805-8
- 64 ☆ Simonato A, Gregori A, Varca V et al. Penile dermal flap in patients with Peyronie's disease: long-term results. J Urol 2010; 183: 1065-8
- 65 Cormio L, Zucchi A, Lorusso F et al. Surgical treatment of Peyronie's disease by plaque incision and grafting with buccal mucosa. Eur Urol 2009; 55: 1469-75
- 66 Ainayev Y, Zhanbyrbekuly U, Gaipov A, et al. Surgical Reconstruction of Penile Curvature due to Peyronie's Disease by Plaque Incision and Buccal Mucosa Graft. J Sex Med. 2021;18(7):1308-1316. doi:10.1016/j.jsxm.2021.04.009
- 67 Salem EA, Elkady EH, Sakr A, et al. Lingual mucosal graft in treatment of Peyronie disease. Urology 2014; 84:1374-7.
- 68 Fabiani A, Servi L, Fioretti F, et al. Buccal mucosa is a promising graft in Peyronie's disease surgery. Our experience and a brief literature review on autologous grafting materials. Arch Ital Urol Androl 2016; 88: 115-21.
- 69 Kargi E, Yesilli C, Hosnutek M, Akduman B, Babuccu O, Mungan A. Relaxation incision and fascia lata grafting in the surgical correction of penile curvature in Peyronie's disease. Plast Reconstr Surg 2004; 113: 254-9
- 70 ☆ El-Sakka AI, Rashwan HM, Lue TF. Venous patch graft for Peyronie's disease. Part II: outcome analysis. J Urol 1998; 160: 2050-3
- 71 Wimpissinger F, Parnham A, Gutjahr G, Maksys S, Baierlein M, Stackl W. 10 Years' Plaque Incision and Vein Grafting for Peyronie's Disease: Does Time Matter? J Sex Med 2016; 13: 120-8.
- 72 Kadioglu A, Salabas E, Ozmez A, et al. Peyronie's disease surgery: surgical outcomes of 268 cases. Turk J Urol 2018;44: 10-15.
- 73 ☆ Chun JL, McGregor A, Krishnan R, Carson CC. A comparison of dermal and cadaveric pericardial grafts in the modified Horton-Devine procedure for Peyronie's disease. J Urol 2001; 166: 185-8
- 74 ☆ Levine LA, Estrada CR. Human cadaveric pericardial graft for the surgical correction of Peyronie's disease. J Urol 2003; 170: 2359-62
- 75 Kalsi JS, Christopher N, Ralph DJ, Minhas S. Plaque incision and fascia lata grafting in the surgical management of Peyronie's disease. BJU Int 2006; 98: 110-4
- 76 Sayedahmed K, Rosenhammer B, Spachmann PJ, Burger M, Aragona M, Kaftan BT, Olianas R, Fritsche HM. Bicentric prospective evaluation of corporoplasty with porcine small intestinal submucosa (SIS) in patients with severe P disease. World J Urol 2017;35: 1119-1124.
- 77 Kovac JR, Brock GB. Surgical outcomes and patient satisfaction after dermal, pericardial, and small intestinal submucosal grafting for Peyronie's disease. J Sex Med 2007; 4: 1500-8
- 78 ☆ Knoll LD. Use of small intestinal submucosa graft for the surgical management of Peyronie's disease. J Urol 2007; 178: 2474-8
- 79 Lee EW, Shindel AW, Brandes SB. Small intestinal submucosa for patch grafting after plaque incision in the treatment of Peyronie's disease. International Brazilian Journal of Urology 2008; 34: 191-6
- 80 Rosenhammer B, Sayedahmed K, Fritsche HM, Burger M, Kubler H, Hatzichristodoulou G. Long-term outcome after grafting with small intestinal submucosa and collagen fleece in patients with Peyronie's disease: a matched pair a Int J Impot Res 2019;31: 256-262.
- 81 ☆ Breyer BN, Brant WO, Garcia MM, Bella AJ, Lue TF. Complications of porcine small intestine submucosa graft for Peyronie's disease. J Urol 2007; 177: 589-91
- 82 Egydio PH, Lucon AM, Arap S. Treatment of Peyronie's disease by incomplete circumferential incision of the tunica albuginea and plaque with bovine pericardium graft. Urology 2002; 59: 570-4
- 83 Otero JR, Gomez BG, Polo JM, et al. Use of a lyophilized bovine pericardium graft to repair tunical defect in patients with Peyronie's disease: experience in a clinical setting. Asian J Androl 2016; Jan 22. Epub ahead of print
- 84 Fiorillo A, Drogheitti M, Palmisano F, et al. Long-term outcomes after plaque incision and grafting for Peyronie's disease: comparison of porcine dermal and bovine pericardium grafts. Andrology. 2021;9(1):269-276. doi:10.1111/and.13841
- 85 Horstmann M, Kwol M, Amend B, Hennenlotter J, Stenzl A. A self-reported long-term follow-up of patients operated with either shortening techniques or a TachoSil grafting procedure. Asian J Androl 2011; 13: 326-31
- 86 Hatzichristodoulou G, Fiechtner S, Gschwend JE, Kubler H, Lahme S. Suture-free sealing of tunical defect with collagen fleece after partial plaque excision in Peyronie's disease: long-term outcomes of the Sealing technique. Eur Urol 2017;16(3):e2152.
- 87 ☆ Hatzichristodoulou G, Fiechtner S, Pyrgidis N, Gschwend JE, Sokolakis I, Lahme S. Suture-Free Sealing of Tunical Defect with Collagen Fleece after Partial Plaque Excision in 319 Consecutive Patients with Peyronie's Disease Sealing Technique. J Urol. 2021;206(5):1276-1282. doi:10.1097/JU.0000000000001933
- 88 ☆ Licht MR, Lewis RW. Modified Nesbit procedure for the treatment of Peyronie's disease: a comparative outcome analysis. J Urol 1997; 158: 460-3
- 89 Hiltunen R, Nieminen K, Takala T et al Low-weight polypropylene mesh for anterior vaginal wall prolapsea randomized controlled trial. Obstet Gynecol 2007; 110:455.
- 90 † Levine LA and Burnett AL. Standard operating procedures for Peyronie's disease. J Sex Med 2013;10: 230-244
- This article reviewed recent medical literatures and combined with expert opinions regarding the management of PD and provided recommendations and Standard Operating Procedures (SOPs) based on best evidence for diagnosis and treatment of PD. This article can be used as the resource to understand the current knowledge regarding PD and its management (surgical or non-surgical)
- 91 Levine LA, Greenfield JM, Estrada CR. Erectile dysfunction following surgical correction of Peyronie's disease and a pilot study of the use of sildenafil citrate rehabilitation for postoperative erectile dysfunction. J Sex Med 2005; 2: 2-
- 92 Terrier JE, Tal R, Nelson CJ, Mulhall JP. Penile Sensory Changes After Plaque Incision and Grafting Surgery for Peyronie's Disease. J Sex Med. 2018;15(10):1491-7.
- 93 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
- 94 Levine LA, Dimitriou RJ. A surgical algorithm for penile prosthesis placement in men with erectile failure and Peyronie's disease. Int J Impot Res 2000; 12: 147-51
- 95 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(1):51-9.

- 96 ☆ Montorsi F, Guazzoni G, Bergamaschi F, Rigatti P. Patient-partner satisfaction with semirigid penile prostheses for Peyronie's disease: a 5-year followup study. *J Urol.* 1993;150(6):1819-1821. doi:10.1016/s0022-5347(17)355
- 97 Ghanem HM, Fahmy I, el-Meleigy A. Malleable penile implants without plaque surgery in the treatment of Peyronie's disease. *Int J Impot Res.* 1998;10(3):171-173. doi:10.1038/sj.ijir.3900324
- 98 Chung E, Solomon M, DeYoung 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. *Med* 2013; 10:2855-60.
- 99 ☆ 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(5):1633-1635.
- 100 Habous M, Tealab A, Farag M, Soliman T, Williamson B, Mahmoud S, et al. Malleable Penile Implant Is an Effective Therapeutic Option in Men With Peyronie's Disease and Erectile Dysfunction. *Sex Med.* 2018;6(1):24-9.
- 101 Habous M, Tal R, Tealab A, Aziz M, Sherif H, Mahmoud S, et al. Predictors of Satisfaction in Men After Penile Implant Surgery. *J Sex Med.* 2018;15(8):1180-6.
- 102 Fernández-Pascual E, González-García FJ, Rodríguez-Monsalve M, Turo J, Martínez-Ballesteros C, Carballido J, 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(2):323-32.
- 103 ☆ Wilson J Urol. 1994 Oct;152(4):1121-3
- 104 ☆ Wilson SK, Delk JR 2nd. A new treatment for Peyronie's disease: modeling the penis over an inflatable penile prosthesis. *J Urol.* 1994;152(4):1121-1123. doi:10.1016/s0022-5347(17)32519-3
- 105 Lucas JW, Gross MS, Barlotta RM, et al. Optimal Modeling: an Updated Method for Safely and Effectively Eliminating Curvature During Penile Prosthesis Implantation. *Urology.* 2020;146:133-139. doi:10.1016/j.urology.2020.08.056
- 106 Hatzchristodoulou 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.* 2 Mar;15(3):416-421
- 107 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.* 20 Jul;129:113-118.
- 108 Shaeer O. Trans-corporeal incision of Peyronie's plaques. *J Sex Med* 2011; 8: 589-93
- 109 Perito, P, Wilson S.K. The Peyronie's plaque "scratch": an adjunct to modeling. *J Sex Med* 2013; 10: 1194-7
- 110 ☆ Antonini G, De Berardinis E, Del Giudice F, et al. Inflatable Penile Prosthesis Placement, Scratch Technique and Postoperative Vacuum Therapy as a Combined Approach to Definitive Treatment of Peyronie's Disease. *J Uro* 2018;200(3):642-647. doi:10.1016/j.juro.2018.04.060
- 111 Egydio PH, Kuehhas FE, Valenzuela RJ. Modified sliding technique (MoST) for penile lengthening with insertion of inflatable penile prosthesis. *J Sex Med* 2015; 12: 1100-4.
- 112 Egydio PH, Kuehhas FE. Penile lengthening and widening without grafting according to a modified 'sliding' technique. *BJU Int* 2015; 116:965-72.
- 113 Egydio PH, Kuehhas FE. The multiple-slit technique (MUST) for penile length and girth restoration. *J Sex Med* 2017;15: 261-269.
- 114 Rolle L, Falcone M, Ceruti C, 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 erectile dysfunction. *BJU Int* 2016;117:814-20.
- 115 Wilson SK, Mora-Estaves C1, Egydio P, Ralph D, Habous M, Love C, Shamsodini A, Valenzuela R, Yafi FA. Glans Necrosis Following Penile Prosthesis Implantation: Prevention and Treatment Suggestions. *Urology.* 2017 Sep;107 doi: 10.1016/j.urology.2017.06.020. Epub 2017 Jun 23.
- 116 Clavell-Hernandez J, Wang R. Penile Size Restoration with Nondegloving Approach for Peyronie's Disease: Initial Experience. *J Sex Med* 2018;15(10): 1506-1513.
- 117 Grasso M, Lania C, Fortuna F, Blanco S, Piacentini I. Preservation of cavernosal erectile function after soft penile prosthesis implant in Peyronie's disease: long-term followup. *Advances in Urology* 2008; 646052
- 118 Austoni E, Colombo F, Romano AL, Guarneri A, Kartalas G, I, Cazzaniga A. Soft prosthesis implant and relaxing albugineal incision with saphenous grafting for surgical therapy of Peyronie's disease: a 5-year experience and long-t follow-up on 145 operated patients. *Eur Urol* 2005; 47: 223-9
- 119 Chung E, Solomon M, DeYoung 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. *Med* 2013; 10:2855-60.
- 120 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.
- 121 Chung H, 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.
- 122 Yavuz U, Ciftci S, Ustuner M, Yilmaz H, Culha M. Surgical Treatment of Erectile Dysfunction and Peyronie's Disease Using Malleable Prosthesis. *Urol J* 2015; 12:2428-33.
- 123 Khera M, Bella A, Karman E, Brant W, Christine B, Kansas B, et al. Penile Prosthesis Implantation in Patients With Peyronie's Disease: Results of the PROPPER Study Demonstrates a Decrease in Patient-Reported Depression. *Med*. 2018;15(5):786-8.
- 124 Bole R, Jimbo M, Parikh N, et al. Patient Attitudes Towards Surgical Management of Peyronie's Disease Prior to Men's Health Consultation. *Urology.* 2021;153:199-203. doi:10.1016/j.urology.2021.02.026
- 125 Shiraishi K, Shimabukuro T, Matsuyama H. The prevalence of Peyronie's disease in Japan: a study in men undergoing maintenance hemodialysis and routine health checks. *J Sex Med.* 2012
- 126 Dibenedetti DB, Nguyen D, Zografas L, Ziemiecki R, Zhou X. A Population-Based Study of Peyronie's Disease: Prevalence and Treatment Patterns in the United States. *Adv Urol.* 2011;2011:282503. doi:10.1155/2011/282503
- 127 Henry et al. Prospective evaluation of postoperative penile rehabilitation: penile length/girth maintenance 1 year following Coloplast Titan inflatable penile prosthesis. *J Sex Med.* 12 (5): 1298-304, 2015