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Outcomes of surgical treatment of Peyronie's disease

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The aims of the present review were to assess the literature on published outcomes and complications associated with surgical treatments for Peyronie's disease (PD) and to assist clinicians in the effective management of PD by increasing understanding and awareness of the outcomes associated with current surgical treatment options. A PubMed literature search was conducted to identify relevant, peer-reviewed clinical and review articles published between January 1980 and October 2013 related to outcomes of surgical correction of PD. Search terms for this non-systematic review included 'Peyronie's disease', 'outcomes', 'complications', 'erectile dysfunction or ED', 'patient expectation', and 'patient satisfaction'; search terms were searched separately and in combination. Case studies and editorials were excluded, primary manuscripts and reviews were included, and bibliographies of articles of interest were reviewed and key references were obtained. Assessment of the study design, methodology, clinical relevance and impact on the surgical outcomes of PD was performed on the sixty-one articles that were selected and analysed. Currently, there are several investigational minimally invasive and non-surgical treatment options for PD; however, surgical treatment remains the standard of care for patients with stable disease and disabling deformity or drug-resistant erectile dysfunction. Each of the different surgical procedures that are used for treatment of PD, including tunical shortening, tunical lengthening (plaque incisions or partial excision and grafting), and use of inflatable penile prostheses, carries its own advantages and disadvantages in terms of potential complications and postoperative satisfaction. Because of the variety of ways that PD may present in affected patients, no single, standard, surgical treatment for this disorder has prevailed and multiple variations of each type of procedure may exist. Surgical outcomes of the most commonly used procedures are not substantially different; therefore, the appropriateness of each treatment option may often depend on disease and patient characteristics (e.g. deformity and erectile function). Surgical algorithms have been published to guide surgeons and patients through the selection of surgical procedures in the absence of conclusive, long-term outcome data. Accumulating data on outcomes associated with established procedures, modifications to these procedures, and new surgical techniques and materials may serve to further guide practice and refine evidence-based selection of the surgical approach.

Keywords

Peyronie's disease, surgical treatment, outcomes, complications, erectile dysfunction

Introduction

Peyronie's disease (PD) is a progressive, two-phase medical condition where disordered collagen deposition replaces the normal elastic fibres of the tunica albuginea, resulting in palpable collagen plaque development in the tunica albuginea of the penis [1]. The acute (active) phase of PD is characterized by penile inflammation, occasionally associated with pain on palpation with erections and/or during sexual activity, and progression in plaque size and curvature deformity [1,2]. Resolution of inflammation and stabilization of plaque size and curvature deformity mark the chronic (stable) phase of disease [2,3]. For a small subset of men, PD may improve spontaneously within 1 year of diagnosis [2,4]. For the remaining patients, the disease may stabilize (45%) or progress (40%) [4]. Although the aetiopathophysiology of PD is not clear, it appears that a genetic predisposition and/or autoimmunity, trauma and inflammation may all play an important role [5].

The estimated prevalence rates for PD among men in the general population range from 3 to 9% [1,6]. Traditionally, PD has been considered a rare disorder; however, it is possible that its prevalence has been under-reported as men may not seek treatment because of embarrassment or a lack of awareness of available treatments, or because the symptoms are not disabling enough in the patient's opinion to warrant treatment [6]. PD results in significant negative physical,

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psychosocial and quality-of-life consequences, probably as a result of coital difficulties and psychological impact [1,7]. Among men with PD, clinically meaningful depression was reported in 48% [7]. A total of 81% of men with PD reported emotional problems, and 54% had relationship problems [8]. Loss of penile length and difficulty with intercourse are strong risk factors for these problems [8].

The burden of PD is amplified by the fact that its aetiology and pathophysiology are not fully understood [2]. This has made diagnosis and treatment challenging and has limited the establishment of robust evidence to support therapeutic options [2]. A detailed preoperative history and physical examination (including measurement of stretched penile length) are essential for diagnosis and treatment plan formulation [1,9]. It is advisable to perform dynamic duplex ultrasonography on all patients undergoing surgery and/or those with erectile dysfunction (ED) to allow the practitioner to have a detailed objective assessment of the penile curvature deformity, plaque calcification and vascular flow [1,9]. Findings of the thorough and accurate assessment will strongly influence subsequent management [1].

A detailed preoperative discussion with each patient on the cause and mechanism of action of the disease and the realistic outcomes of the selected surgical procedure is essential for managing expectations and postoperative satisfaction [9,10]. Moreover, surgeons should emphasize that the main goal of surgery is optimum return of function through correction of the curvature deformity rather than restoration to the pre-PD state [3,10].

Investigational, first-line medical or minimally invasive treatments for PD may be appropriate for men with unstable or progressive deformity who are in the acute phase or who have painful erections. They may also be used to treat men who are in the chronic phase and those who are not interested in or psychologically ready for surgery [1,11]. These treatment options include: oral medications, topical agents, intralesional injections, mechanical stretching or vacuum devices, and extracorporeal shockwave therapy [1,2]. Little high-level, evidence-based information is currently available for minimally invasive therapies used in patients with PD.

Although some minimally invasive therapies have been shown to stabilize collagen plaque formation [1,2], surgery remains a treatment option for penile deformity correction in men with stable disease with and without ED [1,12]. This review is intended to assist clinicians in the effective management of PD by increasing understanding and awareness of the outcomes associated with current surgical treatment options.

Surgical Treatment Algorithm

The aim of surgical treatment is to straighten the penile curvature deformity, preserve or restore erectile function, and preserve penile length and girth [10,13]. Standard surgical procedures for PD involve tunical shortening, tunical lengthening (plaque incisions or partial excision and grafting), or penile prosthesis implantation [10]. No single surgical method has emerged as the standard of care [2]. Procedural decision-making should include considerations of the nature and location of the plaque, degree of penile curvature deformity, baseline erectile function and surgeon's experience, as well as patient preference (Fig. 1) [3,11,13,14].

Published evidence-based guidelines recognize certain patient disease characteristics as indications for surgical intervention: deformity that impairs sexual function (e.g. severe penile bending, penile instability attributable to hourglass, or other narrowing deformities); stable disease/cessation of inflammatory disease process; extensive plaque calcification; failed minimally invasive treatment; and patient desire for rapid and reliable results [1,3].

Baseline evaluation for PD should include a detailed medical history that ascertains disease onset, duration, associated pain and penile deformity [1]. Suggested evaluative objective measures include penile duplex Doppler ultrasonography, stretched penile length, and plaque location (it should be noted that plaque size measurement is not considered a reliable assessment for treatment response) [1]. Additionally, intracavernosal injection of a vasoactive agent to induce erection is advisable to assess accurately the degree of penile curvature and other deformities. Together, these measures can assist in formulating a treatment plan [15].

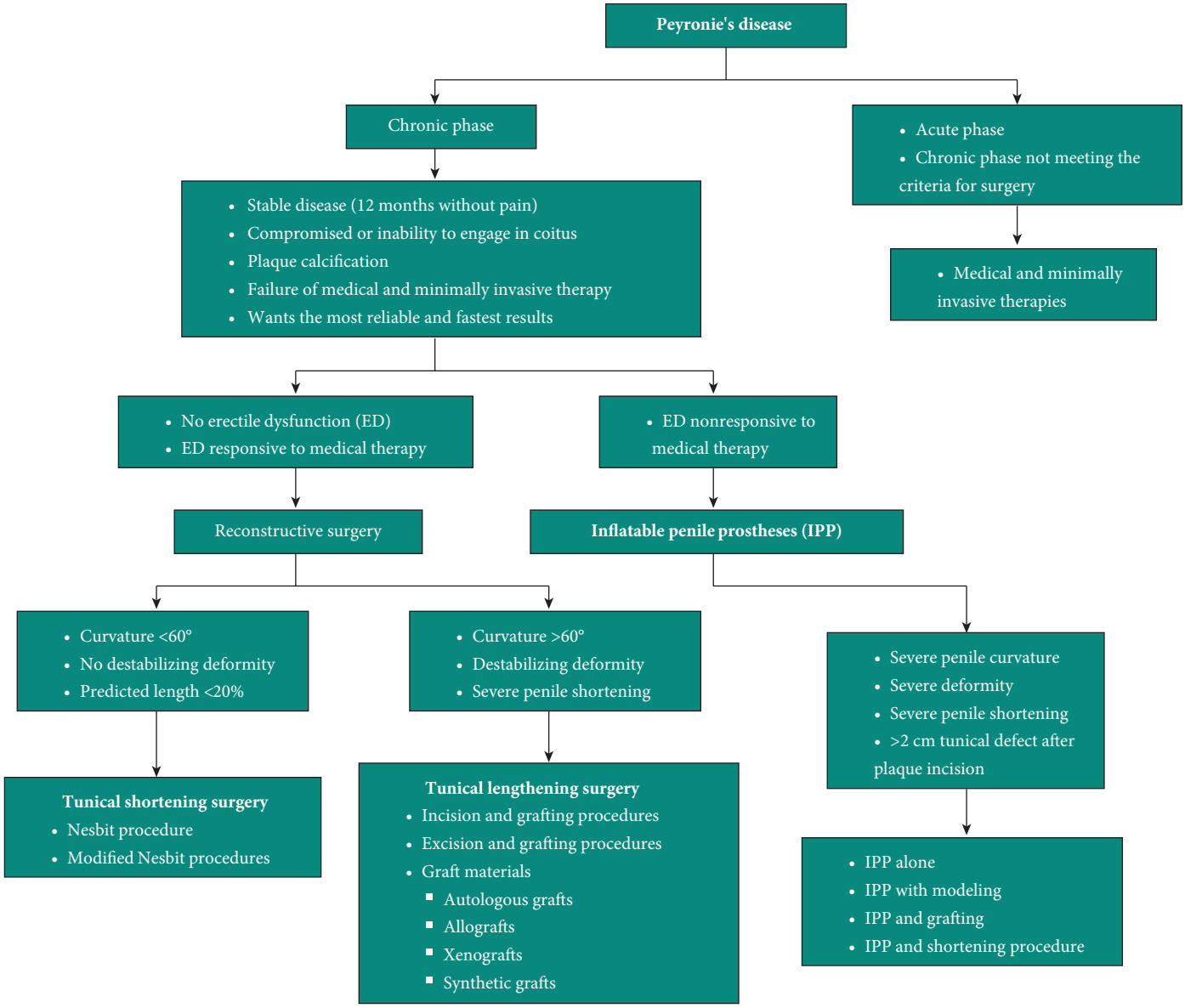
Outcomes of PD Surgical Correction

Tunical Shortening Procedures

Indications for tunical shortening include: adequate preoperative rigidity with or without pharmacotherapy, adequate penile length, simple curvature <60°, distal penile curvature with no hourglass deformity or hinge, or assumed loss of length <20% of total erect length [1,3,11]. Tunical shortening procedures include the Nesbit, modified Nesbit and penile plication variations (Table 1) [16–27]. In brief, the Nesbit entails an elliptical excision of the tunica albuginea contralateral to the area of maximal curvature, thereby shortening the longer side of the tunica albuginea to match the length to the shorter side [1,2,16]. The Nesbit procedure was the original tunical shortening technique and was initially used for the correction of congenital penile curvature caused by corporal disproportion. Modifications of tunical shortening techniques include the Yachia [20], Giammusso [21], Lemberger [22] and Essed-Schröeder [25] techniques, the 16- or 24-dot procedure [23], the penoscrotal plication procedure [26] and tunica albuginea plication [18] (Table 1 [16–36]).

Reported success of tunical plication in correcting penile deformity associated with PD varies depending on technique,

Fig. 1 Surgical algorithm for patients with chronic phase PD [3,11,13,14]. IPP, inflatable penile prostheses. Adapted with permission from Macmillan Publishers Ltd, from 'Current status of the surgical management of Peyronie's disease,' Kadioglu A, et al., *Nat Rev Urol.* 2011; 8: 95–106; permission conveyed through Copyright Clearance Center, Inc.



assessment instrument, study population and setting; success rates range from 42 to 100% [17,24,28]. Penile length, degree (>60°), and direction of curvature deformity (ventral curve) correlate with length lost after this procedure [37] and, consequently, satisfaction. Overall satisfaction with the Nesbit and plication procedures ranged from 76.2 to 100% [16,27]. Primary factors contributing to satisfaction included penile straightening and improved sexual performance [24]. Dissatisfaction was generally associated with postoperative penile shortening, ED and change of penile shape and sensation [1,24].

Horstmann et al. [28] conducted a retrospective chart review and evaluated 32 patients with PD who underwent either the Essed-Schroeder ($n = 16$) or Nesbit ($n = 16$) tunical shortening procedure. After a mean follow-up of 70 months, 62% of patients reported satisfaction with postoperative sexual intercourse at least 50% of the time, 44% reported that their situation had improved vs 31% who reported that their situation worsened, and overall, 41% were satisfied with their current condition. Moreover, ~60% of patients stated that they would choose the same intervention again [28]. Penile shortening after surgery is very common; however, it typically

Table 1 Outcomes of surgical treatment of PD.

Procedure	Author, date	Patients, *N*	Mean follow-up, months	Surgical outcomes (%)					
				Straightening	Shortening	Postoperative ED	Sensory change	Pain	Satisfaction
Tunical shortening procedures									
Nesbit	Syed et al., 2003 [16]	57	84.0	61.9	50.0	12.2[‡]	21.4	NR	76.2
Tunical albuginea plication	Paez et al., 2007 [17]	76	70.5	42.1	NR	60.5	65.8	27.6	NR
	Taylor et al., 2008 [18]	61	72.0	93.0	18.0	10.0	31.0	NR	84.0
Yachia procedure	Daitch et al., 1999 [19]	19	24.1	93.0	57.0	7.1	0.0	0.0	79.0
	Rehman et al., 1997 [20]	26	22.0	73.1	73.1	23.1[§]	19.2	NR	77.0
Giammusso procedure	Giammusso et al., 2004 [21]	12[a]	20.2	100.0	67.0	8.0	0.0	0.0	83.0
Lemberger procedure	Lemberger et al., 1984 [22]	19	10.0	94.7	NR	33.3	5.3	0.0	78.9
16- or 24-dot procedure	Gholami et al., 2002 [23]	132[b]	6.0 to 30.0 (range)	93.0	41.0	NR	6.0	11.0	96.0[¶]
Essed-Schröder tunical plication	Van der Horst et al., 2004 [24]	28[c]	30.0	100.0	74.0	35.7	28.0	14.3	78.0
	Frieddrich et al., 2000 [25]	31[d]	22.0	81.0	19.0	3.0	6.5	26.0	81.0
Penoscrotal plication procedure	Dugi et al., 2010 [26]	48[e]	4.0 to 6.0 weeks	93.0	0.0	NR	0.0	6.0	93.0
Tunical plication combined with plaque thinning with carbide burs	Ding et al., 2010 [27]	18	50.5	83.3	66.7	0.0	NR	NR	100.0
Tunical lengthening procedures									
Dermal graft	Chung et al., 2010 [29]	6	101.8	50.0	17.0	Significantly lower than preoperative ED ($P < 0.01$)	13.0	NR	35.0
Tutoplast*		23	79.2	87.0	17.0				
SIS		17	75.5	76.6	29.0				
Cadaveric pericardial graft	Levine et al., 2003 [31]	40	22.0	98.0	33.0	30.0[†]	2.0	NR	NR
Dermal flap	Simonato et al., 2010 [30]	22	95.0	63.6	NR	31.8	NR	NR	40.9
TachoSil®†	Horstmann et al., 2011 [28]	43	63.0	84.0	93.0	2.3 out of 4 EHS	16.0	7.0	51.0
Penile prosthesis implantation									
Inflatable penile prosthetic implantation	Levine et al., 2010 [32]	90	49.0	4.0	3.0	NR	2.0	NR	84.0
	Levine et al., 2000 [33]	46	39.0	100.0	7.0	0.0	9.0	NR	NR
Soft, silicon, axially resistant, prosthetic cylinders	Austoni et al., 2005 [34]	80	113.0	100.0	NR	0.0	5.0	7.5	95.0
Silicon soft dynamic antiextrusion prosthetic implantation	Grasso et al., 2008 [35]	12	72.0	100.0	NR	100.0	NR	NR	91.0
Transcorporeal incision	Shaeer et al., 2010 [36]	16	14.0	100.0	NR	100.0	0.0	NR	100.0

*NR, not reported; EHS, erection hardness score. *Commercially available, modified human fascia lata that can act as a scaffold to allow tunical regeneration (Mentor Corp.) [47]. †A surgical patch that combines the bioactive mechanism of action of human coagulation factors, fibrinogen and thrombin, with the mechanical support of a [equine] collagen patch (Nycomed GmbH) [28]. ‡ED worsened after surgery. §Persistent preoperative ED. ¶100% satisfaction in 12 patients who had undergone failed Nesbit procedures. Combined results for patients with congenital penile curvature (CPC) and Peyronie's disease (PD): [a]CPC, n = 8; PD, n = 4; [b]CPC, n = 16; PD, n = 116; [c]CPD (congenital penile deviation), n = 17; PD, n = 19; [d]CPC, n = 19; PD, n = 12; [e]CPC, n = 3; PD, n = 45.*

does not affect erectile function [2,27]. A review of surgical options for PD documented the following complications of the Nesbit procedure (n = 612; mean follow-up: 21–84 months) and modified Nesbit procedure (n = 127; mean follow-up: 12–50 months): recurrence of penile curvature deformity (7.7–10.6% by >30°), erectile dysfunction (3.25–23.1%), penile haematoma (0–8.9%), penile narrowing or induration (0–16.7%), urethral injury (0–1.4%), suture granuloma (0–1.9%), penile or glans hypoesthesia (0–21.4%) and phimosis (0–4.8%) [14].

Tunical Lengthening Procedures

Tunical lengthening procedures are appropriate for patients with full to near-full preoperative rigidity with or without oral pharmacotherapy, complex penile curvature deformity >60°, large size plaques, destabilized hourglass or hinge effect, and short penile length [1,3,11]. Tunical lengthening procedures can be achieved by either plaque incision and grafting or partial plaque excision and grafting (Table 1) [3,28–31]. Partial plaque excision is preferred over total plaque excision because the latter may cause irreversible dysfunction of the veno-occlusive mechanism of the penis, resulting in high rates of postoperative ED [38]. Relaxing incisions plus careful dissection of calcified plaque material may be effectively employed to change the shape of the penis and permit a smaller graft to be used [39].

A number of graft materials are currently in use and are categorized as autologous grafts [40–45], allografts [18,46–48], animal xenografts [28,49–52], and synthetic grafts [53] (Table 2 [18,28,40–53]) [1,13]. Although the ideal graft has not been identified, it has been suggested that grafts should approximate the strength and elastic characteristics of normal tunica albuginea, have minimal morbidity and tissue reaction, and should be readily available. Grafts should also be pliable and easy to suture, strong and thin, inexpensive, resistant to infection, and able to preserve erectile capacity [2,3]. Currently, available graft materials are associated with potential complications, some of which are commonly linked to significant patient dissatisfaction (Table 2) [29]. It is generally thought that complications related to choice of autologous graft material are of small consequence; therefore, disease and patient characteristics, surgeon experience, patient preference and cost-effectiveness are much more important to consider when selecting autologous graft materials [3].

Off-the-shelf allografts and xenografts, such as processed pericardium and small-intestinal submucosa (SIS), respectively, are commonly used grafts that have garnered recent interest [13]. Reduced postoperative ED has been reported after using Tutoplast® (Mentor Corp, Santa Barbara, CA, USA) and Stratasis® (Cook Urological, Bloomington, IN, USA) allografts [47,48]. Concerns about synthetic grafts (e.g. Dacron®, Gore-Tex® or silicone) [13] include risk of local inflammation, infection and intense fibrosis palpability [54]. The long-term histological changes associated with various graft materials using a rat model indicated that cadaveric pericardium allowed complete penile expansion and was strong enough to withstand normal intracorporeal pressures [55]. Ferretti et al. [56] engineered a new autologous tunica albuginea graft by growing fibroblasts on a polyglycolic acid scaffold *in vitro*. Morphological and functional outcomes of the tissue-engineered graft in rats were promising, but extensive study in humans is required before this type of fibroblast-seeded scaffold can be considered for routine care [56]. As with mesenchymal stem cells, which are adult stem cells capable of self-renewal, adipose tissue-derived stem cells have the potential to restore damaged tissue, such as the tunica albuginea. Seeding adipose tissue-derived stem cells onto SIS grafts for tunica albuginea reconstruction resulted in significant cavernosal tissue preservation and maintained erectile responses, similar to controls, in a rat model of bilateral incision of tunica albuginea compared with sham-operated animals and rats grafted with SIS graft alone [57].

Success and satisfaction rates of tunical lengthening procedures are shown in Table 1. These procedures are highly variable depending on the graft used (Table 2). Research has shown that preoperative erectile status is the only variable that may be predictive of occurrence of postoperative ED and, consequently, success rate and patient satisfaction [58,59]. In a retrospective study of 218 men who underwent surgery for PD, ED was reported in 21% of patients after partial plaque excision and pericardial grafting [58]. Some evidence suggests that larger grafts may be associated with eventual loss of erectile function [55]. Overall satisfaction with tunical lengthening procedures reported between 2005 and 2010 ranged from 41 to 93% (Tables 1,2) [30,47]. A study by Horstmann et al. [28] recorded a 51% patient-reported satisfaction in 43 patients with PD who underwent a plaque incision/excision and defect covering with a TachoSil® graft (Nycomed GmbH, Konstanz, Germany) (Table 1). Another study of 112 patients with PD who underwent plaque incision and venous patch grafting reported that 92% of the patients believed that surgery improved their psychological state and their relationship with their partner [45]. Similar satisfaction rates have been reported by patients who underwent autologous graft surgery with rectus sheath graft (58%) and fascia lata (100%) (Table 2) [40,44].

Despite the high satisfaction rate, autologous grafts are associated with harvest site comorbidities and penile complications and may require a second incision, such as with venous grafts [3]. Synthetic grafts are often associated with increased risk of infection, fibrosis resulting from significant inflammation around the graft site, contracture because of inelasticity of the material used, and risk of allergic or foreign-body reaction [54,55]. Compared with the Nesbit

Table 2 Graft materials used in PD 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	Satisfaction
Autologous grafts	Rectus sheath	Craatz et al., 2006 [40]	12	4 to 10 (range)	100.0	NR	0.0	NR	NR	58.3
	Tunica vaginalis	O'Donnell et al., 1992 [41]	25	42.2	88.0	96.0	68.0	16.0	NR	NR
	Dermal graft	Goyal et al., 2008 [42]	11	6 to 24 (range)	81.8	NR	9.1	18.2	0.0	81.8
	Buccal mucosa	Cormio et al., 2009 [43]	15	13.1	100.0	0.0	0.0	0.0	NR	93.3
	Fascia lata graft	Kargi et al., 2004 [44]	12	10	100.0	0.0	0.0	NR	NR	100.0
	Venous patch graft	El-Sakka et al., 1998 [45]	112	18	96.0	170	12.0	10.0	6.2	92.0
Allografts	Pericardium	Chun et al., 2001 [46]	9	6	55.5	NR	11.0	0.0	NR	88.9
	Tutoplast®*human pericardial grafting	Taylor et al., 2008 [18]	81	58	91.0‡	33.0	32.0	31.0	NR	75.0
	Fascia lata Tutoplast* graft	Kalsi et al., 2006 [47]	14	31	79.0	28.6	7.1	7.1	NR	93.0
	Four-layer Stratasis grafts	Kovac et al., 2007 [48]	13	7.8	76.9	46.0	23.0	23.0	NR	84.6
Xenografts	Porcine four-layer SIS	Lee et al., 2008 [49]	13	14 (median)	100.0§	NR	54.0	NR	NR	NR
	Porcine four-layer SIS	Knoll et al., 2007 [50]	162	38	91.0	5.0	21.0	17.0	0.0	NR
	Porcine one-layer SIS	Breyer et al., 2007 [51]	19	15	63.0	63.0	53.0	NR	26.0	Score of 2.7 out of 5.0
	Bovine pericardium graft	Egydio et al., 2002 [52]	33	19.5	87.9	NR	0.0	NR	NR	NR
	TachoSil†	Hortsmann et al., 2011 [28]	43	63.0	41.0	40.0	9.0	7.0 (severe), 16.0 (moderate)	7.0	20.0
Synthetic grafts	Polyethylene terephthalate mesh reinforced silicone sheet patch graft	Licht et al., 1997 [53]	28	22	61.0	30.0	18.0	14.0	NR	30.0

**A commercially available, modified human fascia lata that can act as a scaffold to allow tunical regeneration (Mentor Corp.) [47]. †A surgical patch that combines the bioactive mechanism of action of human coagulation factors, fibrinogen and thrombin, with the mechanical support of a [equine] collagen patch (Nycomed GmbH) [28]. ‡Defined straight as residual curvature of <30°. §Defined straight as residual curvature of 0–15°. ED, erectile dysfunction; NR, not reported.*

procedure, partial plaque excision and synthetic patch grafting (polyethylene terephthalate) resulted in significantly lower rates of curvature corrections ($P = 0.004$) and patient satisfaction ($P < 0.001$), and higher rates of postoperative ED ($P = 0.04$) in patients with PD (Table 2) [48].

Inflatable Penile Prosthesis

Use of a penile prosthesis is indicated when preoperative, medication-refractory ED accompanies PD [1,32,33]. In conjunction with placement of the prosthesis, the surgeon may opt to surgically straighten the penis, as necessary [11]. Infrapubic or penoscrotal incisions are preferred for the insertion of penile prostheses implants in most cases and according to surgeon experience. Malleable and inflatable devices are available (Table 1) [32,34,35], with the latter able to be divided into two- and three-piece devices. Inflatable devices lead to higher functional satisfaction and lower rates of persistent penile curvature deformity compared with malleable devices [3].

Guidelines for penile prosthesis surgery have been published [1,33]. The algorithm calls for manual modelling when residual curvature exceeds 30°. When the post-modelling residual curve is >30°, a plaque-releasing incision should be considered. Finally, a tunica graft is recommended to avoid implant herniation or cicatrix contracture when the defect is >2.0 cm [32]. Transcorporeal approaches, including transcorporeal incision and the scratch procedure, have also been explored as an adjunct to modelling procedures. The aim for these two procedures is to simplify release of the deforming scar or plaque in a more minimally invasive way, potentially reducing the need for extensive modelling and plaque incision and grafting [36,60].

Reported success rates with penile prosthesis implantation ranged from 84 to 100% (Table 1) [32–36]. Satisfaction rates for penile prosthesis implantation in the general population range from 91 to 100% [32,34,35]. The reasons for satisfaction were generally related to surgical outcomes [57]. In a study of inflatable penile prostheses, Levine et al. [32] reported that 91% of patients were satisfied with concealability, 84% were satisfied with ease of inflation, and 71% had no difficulty with deflation. Additionally, 60% of patients reported that their partner was either very satisfied or somewhat satisfied with their outcome [32]. A study comparing patient satisfaction after implantation with either the AMS 700™ CX or Coloplast™ Titan inflatable penile prosthesis [61] reported that both devices provide permanent penile straightening and high patient satisfaction without an increased risk of revision surgery. Of the patients who underwent a three-phase soft penile prosthesis implantation procedure (using soft, silicon, axially resistant, prosthetic cylinders with tunical relaxing incisions and saphenous vein grafting), 88.8% reported that their partners were satisfied with the outcome of surgery, although 12 partners mentioned a difference in the appearance of the penis [34].

Complications associated with penile prostheses include infection, penile shortening, diminished sensitivity, device operation difficulties, persistent curvature and mechanical failure of the prosthesis. Complications encountered in one study of an inflatable prosthetic included mechanical failure (7.7%), device bending and erosion (2.2%) and device infection (1.1%) [32]. Local infections were reported in 8% of patients receiving a soft dynamic anti-extrusion prosthesis [35] and in 7.5% of patients who underwent a three-phase soft penile prosthesis implantation [34]. Glans paresthesia (5%) and preputial oedema necessitating repeat circumcision (10%) were reported with the three-phase soft penile prosthesis implantation [34].

Postoperative Care and Rehabilitation

Postoperative rehabilitation after non-prosthetic surgery may promote erectile function and might also reduce penile shortening [1]. Massage and stretch therapy should be performed twice daily for 4 weeks, starting 2 weeks after surgery. This therapy involves gently and repeatedly pulling the glans away from the body while also gently massaging the graft area. Partner involvement in rehabilitation may lessen postsurgical anxiety. A 6-week course of bedtime phosphodiesterase inhibitor therapy is also recommended and should be initiated 7–10 days after surgery. Phosphodiesterase inhibitors, via the mechanism of increased levels of cGMP in the corpus cavernosum, can result in smooth muscle relaxation, inflow of blood to the corpus cavernosum, and nocturnal erection [59]. Postoperative penile shortening associated with plication or grafting procedures may be reduced by external penile traction therapy initiated when the circumcising incision has healed. Traction should be maintained for 3–6 h per day for 3 months, typically starting at 3–4 weeks postoperatively [62].

Cost and Economic Considerations

The comparative cost-effectiveness of surgical options and materials used to treat PD have not been extensively documented in the literature. Nonetheless, the availability of materials, health insurance coverage, and other cost considerations may play a role in decision-making. Any economic analysis should incorporate the costs of surgical time, labour and materials, as well as resolution of potential complications.

Conclusion

The effective management of PD poses a clinical challenge. Investigational, minimally invasive or non-surgical treatment options are often used as first-line therapy for PD. Surgical

correction remains an important treatment option for patients with PD who have stable disease with disabling deformity or ED. Penile plication surgery is the least invasive and most commonly performed surgical option. Tunical shortening is a simple procedure that is less invasive than other surgical procedures and better preserves erectile function. Disadvantages of tunical shortening are risk of penile shortening (especially after correction of penile curvature deformity >60° or ventral curvature where dorsal plication is necessary) and worsening of an existing hourglass or hinge effect [1,37]. For men with severe deformity (>60°, with or without destabilizing hourglass deformity), plaque incision/excision and grafting is the standard of care for the man with strong preoperative erections. Selection of graft material depends on availability, cost, surgeon's experience, and patient's preference. Together, the patient and the surgeon should weigh the advantages and disadvantages for each procedure and graft material. Saphenous vein and tunica albuginea are the most commonly used autologous grafts [3]. Although patient satisfaction rates after autologous graft surgeries are high, these surgeries are labour-intensive and are often associated with harvest site comorbidities [3]; therefore, surgeons tend to use off-the-shelf allografts and xenografts to avoid autologous graft harvesting and its associated comorbidities and to decrease operating time [1,3]. Other commonly used graft materials include cadaveric pericardium and four-layer SIS [3]. Synthetic grafts have not been adopted into routine use because of their unnatural feel and potential risk for inflammation and fibrosis [54]. Penile prostheses, with straightening manoeuvres as needed, should be reserved for patients with ED that is refractory to oral pharmacotherapy.

Because PD is a heterogeneous disease and has variable presentations, no single, standard, surgical treatment for this disorder has prevailed. The invasive surgical options fo rthis condition are prone to potential complications and postoperative dissatisfaction. Because surgical outcomes are not vastly different among techniques, patient selection may play an important role in choosing the surgical procedure. Accordingly, shared decision-making after published algorithms and guidelines and obtaining preoperative informed consent are essential in managing expectations and, consequently, patient satisfaction in the management of patients with PD.

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Conflict of Interest

C.C.C. is a consultant and speaker for American Medical Systems, Auxilium, GlaxoSmithKline and Lilly. L.A.L. is a consultant for Auxilium and Coloplast, has received payments for lectures from Auxilium, Coloplast and American Medical Systems and has participated in clinical trials for Auxilium.

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Abbreviations: PD, Peyronie's disease; ED, erectile dysfunction; SIS, small-intestinal submucosa.

