

Surgical alternatives for treating Peyronie's disease

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INTRODUCTION

Peyronie's disease (PD), characterized by an acquired plaque-inducing penile deformity, is a common cause of sexual dysfunction in middle-aged men. The prevalence of PD is estimated to be 3.2% among men, largely affecting Caucasians, with a mean age of 57.4 years [1]. Plaque formation on the tunica albuginea causes penile curvature, indentation, or 'hour-glass' deformity. Symptoms may include any of the following: painful erections, pain with intercourse, inability to have intercourse because of the curvature of the penis, erectile dysfunction (ED), and a palpable indurated plaque. Although the aetiology for PD remains a mystery, studies suggest that trauma to the penis leads to subtunical bleeding and subsequent fibrosis along the tunica albuginea with plaque formation [2]. The course of the disease can be variable, with up to 13% regressing spontaneously, 40% progressing if untreated, and 47% showing no change over time [3].

Different treatment options exist for PD; most individuals receive medical treatment before surgery. Numerous methods have been described with varying levels of success, including oral medication, intralesional injection, topical agents, and even extracorporeal shockwave therapy [4]. Treatments should be tailored for each patient, with the most conservative treatment administered first and the ultimate goal being a satisfactory erection for the patient.

SURGERY

Failure in improvement of erections or insufficient erections for intercourse with medical methods is an indication for surgical treatment in men who desire surgery and are

acceptable candidates. The timing of surgery is important; the course of PD in most patients includes an active and a quiescent phase. The active phase, occurring first, is characterized by painful erections, a palpable nodule or plaque, and developing penile deformity with erections. The subsequent quiescent phase is characterized by a stable appearance of the penile deformity, dissolution of the pain, and possible new onset of ED. Surgery should be avoided in the active phase while the penile deformity develops. Although urologists commonly wait 6 months from the onset of the quiescent phase of PD before performing any procedure, it is best to wait at least 1 year based on the experience of Montorsi *et al.* [5], who found that a significant proportion of patients with stable disease for 6 months will have disease recurrence after procedures.

There are three general categories of surgical options for PD; tunical shortening, tunical lengthening/graft, and penile prostheses. Several authors have promoted novel techniques that will also be discussed in this review. Surgical treatments must be tailored to each man with PD. Levine and Lenting [6] reported a surgical algorithm for patients with PD. Tunical shortening surgery is used for men with subjective or objective full erectile capacity, a curvature of $<60^\circ$ and no hour-glass deformity or hinge effect. Tunical lengthening surgery is used for men with subjective or objective full erectile capacity, a complex or bi-dimensional curvature, curvature of $>60^\circ$, or the presence of an hour-glass deformity or hinge effect. They also recommended a penile prosthesis for men with ED and PD. The surgical algorithm from the University of North Carolina (UNC) (Fig. 1) is based on the size of the penis, curvature, erectile function and symptoms, and serves as a guide for treatment decisions.

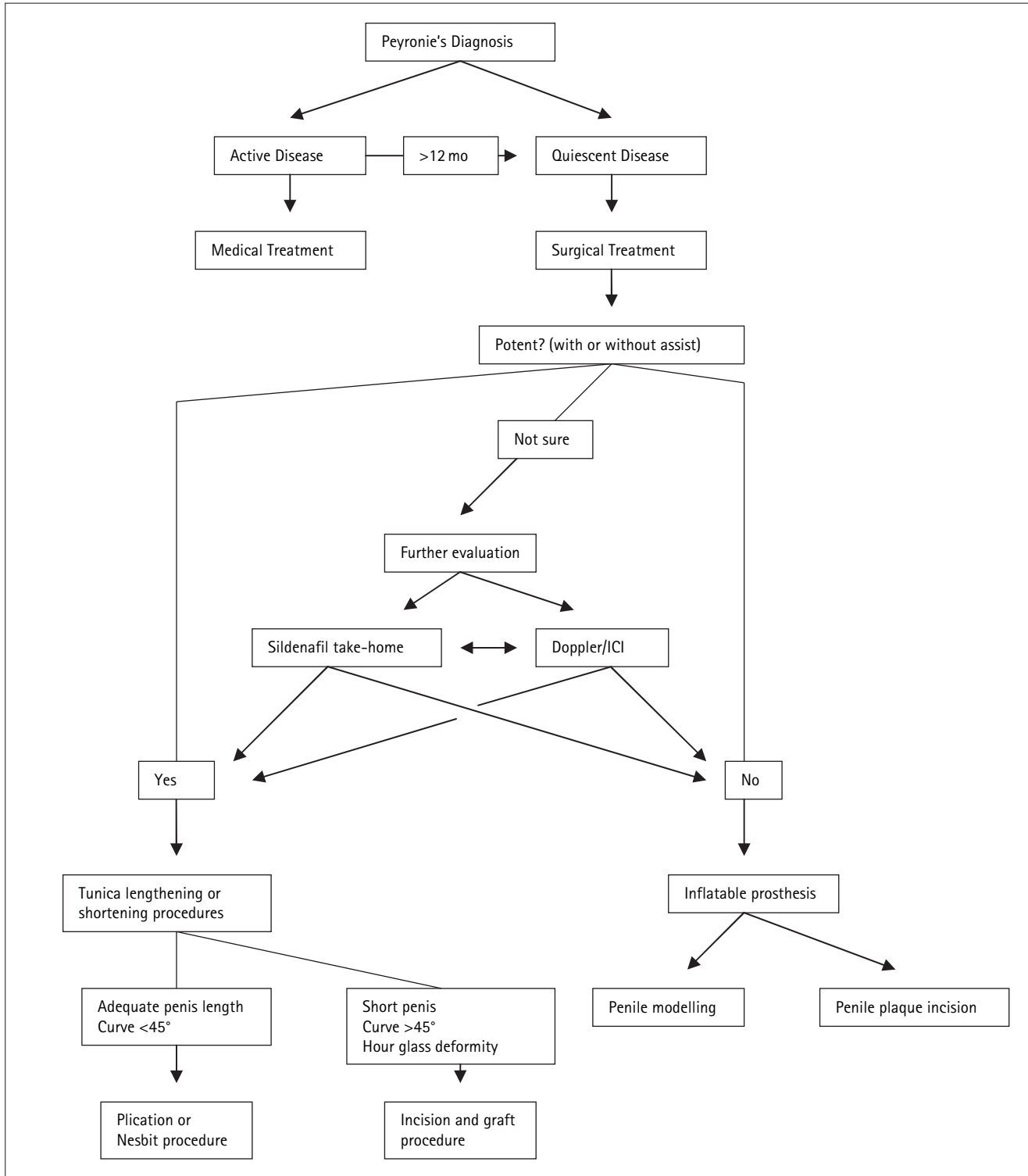
PREOPERATIVE EVALUATION

The evaluation before surgery includes a thorough history, physical examination and

frequently a test for erectile function. A history of penile trauma, potency status, disease course, ability to engage in intercourse, and comorbid factors are important in surgical planning. As discussed above, the natural history of PD includes both an active and quiescent phase, and discussions about disease onset and course are necessary for timing potential procedures. The history of potency is extremely important in planning; men with sufficiently rigid erections, even with assistance, are candidates for penile straightening procedures via plication, a Nesbit or modified Nesbit procedure, or plaque incision and grafting. Men who are unable to achieve sufficiently rigid erections will receive greater benefit from a prosthesis.

For men considering surgery, potency is determined by three possible methods: their history, a sildenafil test at home, or an intracavernosal injection (ICI)/Doppler ultrasonography (DUS) examination. Nocturnal penile tumescence studies (Rigiscan) or infusion cavernosography may be considered, although rarely required. No further invasive studies are necessary if men describe firm erections, regardless of their ability for intercourse, which may be impossible because of curvature. Some authors feel that patients considering surgery should have DUS even if their erections are normal. Montorsi *et al.* [5] reported that DUS is important for detecting subclinical abnormalities in penile haemodynamics and communicating vessels that could possibly lead to ED after surgery if transected. According to Montorsi *et al.* in 50 consecutive men with PD, 10 (20%) had ED by history, yet DUS showed haemodynamic abnormalities in 20 (40%). With ICI/DUS an erection is induced with either alprostadil, prostaglandin E1 or papaverine, with the rigidity, degree and location of curvature then assessed. The plaque size and presence of calcification are then determined with DUS. The latter is a poor prognostic indicator for spontaneous improvement and response to medical therapy. DUS also shows the adequacy of the penile vessels in helping patients determine

FIG. 1. The UNC surgical algorithm for treating PD.



whether they should receive a penile prosthesis. Despite these useful findings, a firm preoperative erection remains the best indication for the likelihood of success for non-prosthetic PD surgery, and the use of ICI/DUS is usually reserved for patients who describe impaired erections or are uncertain of their potency.

Many men have avoided sexual contact since the onset of PD because of the extreme curvature of their penis, and are uncertain of their erectile capability. A home trial of sildenafil with a subsequent follow-up report in the clinic may help in selecting the procedure for these men.

Preoperative counselling should include a discussion of the patients' and partners' expectations, as well potential risks and complications. Patients and partners may have unrealistic expectations of the results and should be carefully counselled beforehand. Also, patients should be warned of the most frequent complications for these procedures, including penile shortening, recurrent curvature, ED, haematoma, penile and glans hypoesthesia, urethral injury and wound infection. Other complications related to particular procedures will be discussed below or identified in the tables.

TUNICAL SHORTENING

THE NESBIT PROCEDURE

This was first described by Nesbit for treating erectile deformities caused by congenital abnormalities [7] and later applied to PD by Pryor and Fitzpatrick [8]. This procedure has a high success rate, with 82% of patients in a large retrospective study able to have intercourse with minimal residual penile deformity [9]; 88% of patients were satisfied with the outcome of the Nesbit procedure in a separate large study, with 82% having a completely straight penis afterward [10]. Table 1 [9–13] shows the experience of authors and their patients in recently published reports.

The procedure involves excision and plication of the tunica opposite the Peyronie's plaque, thus straightening the penis. A circumcision incision is made and the penile skin degloved. An artificial erection is induced by intracorporal saline injection. The area of maximum bend is marked (pen or suture) on

the convex side of the penis (opposite the plaque), and a 5–10 mm transverse ellipse of the tunica albuginea excised. The ellipse excised should be ≈ 1 mm wide for every 10° of curvature. Rehman *et al.* [11] slightly altered the traditional technique by using a partial-thickness shaving of the tunica albuginea rather than a full-thickness cut, proposing that this would decrease intraoperative bleeding and cavernosal damage. Most authors continue to use a full-thickness incision. Buck's fascia is then dissected off the tunica albuginea with the corpus spongiosum for dorsal deformities, or it is dissected off the neurovascular bundles for ventral curvatures. The tunica is closed watertight and horizontally using interrupted suture and buried knots. Because of the increased risk of phimosis circumcision is common at the time of surgery, if needed. An erection is induced to check the results; if straight, Buck's fascia and the skin are closed and a light dressing applied to the penis. A penile block is placed with bupivacaine. This is day-surgery and patients may be discharged after voiding, and are advised to avoid intercourse for 6 weeks while they heal.

Although the results with the Nesbit procedure are excellent for penis straightening, penile shortening occurs in most patients and is a drawback for many men. Shortening rarely prevents sexual intercourse (1.3–11.9%) [9,10,12], but merits discussion with patients before surgery. Pryor [9] thought that penile shortening in patients undergoing the Nesbit procedure is usually insignificant, with 86.6% of patients in his large retrospective study having <1 cm of shortening and only 1.7% reporting that the shortening inhibited sexual activity. These data agree closely with those reported by Savoca *et al.* [10]. Also, satisfaction rates tend to be good, with 75–88% of patients satisfied with the results of their procedure [9–13].

Complications with the Nesbit procedure include recurrent curvature (7.7–10.6% of $>30^\circ$), ED (3.25–22.9%), 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%) [9–13]. This procedure is still a very good option for men with adequate penile length, good erectile function, curvature of $<45^\circ$, and no hour-glass deformity.

THE MODIFIED NESBIT PROCEDURE

Yachia [14] proposed modifications to the Nesbit procedure to decrease the likelihood of disrupting the neurovascular bundle and subsequent glans hypoesthesia. He proposed making a single longitudinal (1–1.5 cm) incision or several smaller longitudinal incisions on the convex side of the tunica, following a similar approach as described above. The incisions are then closed horizontally with buried knots using either absorbable or permanent suture, applying the Heineke-Mikulicz principle. The procedure has a high rate of satisfaction in various reports [13,15,16], although penile shortening remains a common drawback (57–67%). Sulaiman and Gingell [16] found that 40% of patients were concerned about their penile shortening after surgery, with 7.7% claiming that intercourse was unsatisfactory because of it. When Licht and Lewis [13] compared results of the Nesbit, modified Nesbit and tunical incision with grafting, the highest rate of satisfaction (83%) and lowest ED (0%) were with the modified Nesbit. Complications may be similar to those of the traditional Nesbit procedure and glans hypoesthesia is still possible. Table 1 also shows the experience of authors and their patients with the modified Nesbit.

PPLICATION

Plication of the tunica albuginea of an erect penis is less invasive than other procedures and may be completed under local anaesthesia. Reported results vary widely with 'straightening' rates of 57–85% [17–22]. A recent study by Gholami and Lue [18] on the use of plication reported that the recurrence rate of penile curvature at a mean follow-up of 2.6 years was only 15%, and 96% of patients were satisfied with their erection. Others have not found this surgery nearly as successful, with frequent complaints of bothersome sutures, shortening and ED [17,19]. Chahal *et al.* [19] reported that 57% of patients in their study had a deterioration in their quality of life after the procedure, with 90% having a shortened penis (55% 'significantly shorter'), 36% with impaired erections, 32% with glans hypoesthesia, and 34% complaining of bothersome suture knots. Table 2 shows the experience with tunica plication.

Gholami and Lue [18] describe the '16 dot' plication procedure in a large retrospective

TABLE 1 Results of the Nesbit and modified Nesbit procedure in patients with PD

Ref	N	Mean follow-up, months	Straightness %	ED %	Satisfaction %	Shortening, % (cm)	Complications %
Nesbit							
[12]	42	84	61.9 straight 28.6 (<30°) 9.5 severe curve	16.7 worse	47.6 satisfied 28.6 partly satisfied 23.8 unsatisfied	50 no change 50 shorter 11.9 shortening causing SD	21.4 glans hypoesthesia, 16.7 narrow/bumpy areas, 7.1 haematoma, 4.8 phimosis, 2.4 urine retention, 2.4 infection
[10]*	157	72	82.1 straight 15.9 (≤20°) 1.3 (<25°)	13.3 worse – –	87.9 satisfied 12.7 partial 0.6 complete	86 (<1.5) 14 (1.5–3) 1.3 shortening causing SD	8.9 haematoma, 2.5 wound infection, 1.9 phimosis, 1.9 painful knot, 0.6 urethral injury, 0.6 UTI
[9]	359	21	89.4 (<30°) 10.6 (≥30°)	3.25 worse†	66 excellent 16 satisfied 18 poor	86.6 (<1) 8.6 (1–2) 4.7 (>2) 1.7 shortening causing SD	5.3 haematoma, 2.2 wound infection, 1.9 glans hypoesthesia, 1.7 chest infection, 1.4 urethral injury, 1.4 urine retention, 1.1 phimosis, 0.84 suture granuloma, 0.56 UTI, 0.27 painful knot
[13]	28	24	79 straight	4 ED after	79 satisfied	37 (1–2)	14 penile hypoesthesia 4 require subsequent surgery
[11]	26	32	73 straight 19.2 (≤15°) 7.7 (≥30°)	7.7 worse	84.6 satisfied (with cosmetic) 15.4 dissatisfied (with cosmetic)	73.1 (≤1) 23.1 (1–2) 7.7 (>2)	–
Modified Nesbit							
[15]	19	24.1	92.9 straight 7.1 (<20°)	7.1 worse	42.9 very satisfied 35.7 satisfied 7.1 neutral 14.3 dissatisfied	43 no change 57 (1.2–7.5)	–
[13]	30	12	93 straight	0	83 satisfied	67 (1–2) 3.3% shortening causing SD	3 penile hypoesthesia
[16]	78	50	4.8 recurrence	23.1 worse	79.5 satisfied	40 concerned about shortening 7.7 unsatisfactory intercourse (5)	3.8 penile hypoesthesia 3.8 unhappy with circumcision

*17 of 157 had a modified Nesbit for an hour-glass deformity; †Data after 1984 when closer preoperative selection variables initiated; SD, sexual dysfunction.

study. An intracavernosal injection of papaverine is given to induce an artificial erection. The patient is then prepared and a penile block using bupivacaine given. With ventral curvatures a dorsal longitudinal incision or circumcising incision is made according to patient preference (uncircumcised patients desiring to keep their foreskin have longitudinal incisions). Buck's fascia is incised above the neurovascular bundle and an intervascular space developed bluntly between the dorsal vein and the dorsal arteries. Because most nerve fibres are 0.5–1.0 cm lateral to the

dorsal arteries, plication sutures may be placed in this developed space. For dorsal curvature, a ventral longitudinal incision is made down to the dartos fascia overlying the corpus cavernosum. Sutures are placed ≈2 mm lateral to the corpus spongiosum. Lateral curvatures may be treated with either a circumcising or ventral longitudinal incision. After marking the centre of the curve and the entry and exit points of the plicate sutures, two to three pairs of 2–0 braided polyester sutures are placed through the full thickness of the tunica albuginea (four entry or exit

points per suture). The sutures are gradually tied with one surgical knot placed and subsequent clamping. Once all plications are partly tied and clamped, the erect penis is examined. If the penis is adequately straightened the knots are completed and buried. Ideally there will be minimal tension on the plication sutures. At the end of the procedure the dartos fascia is re-approximated over the sutures and the skin closed. A light dressing is placed and ice applied for 1 day. The patient can usually be discharged within 2 h after surgery.

TABLE 2 Results of tunical plication in patients with PD

Ref	N	Mean follow-up, months	Straightness %	ED %	Satisfaction %	Shortening % (cm)	Complications %
[17]	31	–	–	29 worse	58 satisfied 42 dissatisfied	90	–
[18]	124	31.2	85 straight 15 recurrence 3 severe recurrence	6 worse	–	41 (0.5–1.5) 7 shortening causing SD	12 bothersome knots, 11 erectile pain, 9 penis narrowing/indentation, 6 penile hypoesthesia, 4 haematoma, 0.76 foreskin oedema needing circumcision
[19]	44	49.2	29 straight 57 mild, 14 severe deformity	36 impaired (18 before) erections	–	90 55 (significant)	57 deterioration of quality of life, 48 glans hypoesthesia 34 bothersome nodules, 16 penile discomfort on intercourse
[20]	29	–	79.3 straight 20.7 recurrence	37.9 unable to have satisfactory intercourse	81 satisfactory cosmesis 62 satisfactory function	8.30	3.3 glans hypoesthesia 3.3 wound infection 3.3 haematoma
[21]	28	34	57.1 sufficiently straight	28.6 unable to have i/c 3.6 new ED	54 very satisfied 28 satisfied 18 not satisfied	–	17.9 penile/scrotal pain 17.9 bothersome knots
[22]	33	–	–	24.2 worse	–	54.5 shorter 6.1 shortening concern	12.1 glans hypoesthesia

SD, sexual dysfunction.

Gholami and Lue [18] used this procedure in patients with large or complex curvatures, although both the UNC and Lenting/Levine algorithm [6] support grafting techniques in these cases. Complications after surgery can include ED (6–38%), curve recurrence (15–20.7%), penile narrowing (0–9%), haematoma (0–4%), penile or glans hypoesthesia (3–48%), wound infection (0–3%), and bothersome knots (0–34%) [17–22].

The major drawback of the Nesbit procedure, its modifications and plication is penile shortening. While these procedures are often effective at achieving a straight erection with less invasive techniques, many men will avoid the prospect of a shortened penis.

TUNICAL LENGTHENING PROCEDURES

Incision or excision of Peyronie's plaques and placing grafts has been used for patients with severe penile curvature when other operations could result in a shortened, deformed penis, or when patients have narrowing or hour-glass deformities. Lowsley

and Boyce [23] first reported a series of patients with PD who had plaque excision and grafting of the corporal defect with fat, quoting a 66% success rate. Horton and Devine [24] modified this technique by patching the corporal defect with an autologous dermal graft for improved graft tensile strength, to withstand corporal engorgement during erection.

Different materials have since been used for grafts including tunica vaginalis [25], vein [5,26–29], synthetics [13,30], dura mater [31], porcine small intestine submucosa (SIS) [32] and cadaveric or bovine pericardium [33–35]. The ideal graft for penile reconstruction has the following characteristics: it is pliable and compliant, low antigenicity risk, low infection transmission risk, minimal inflammation, high tensile strength, is available packaged, in many sizes and at a reasonable cost [35]. At UNC, cadaveric pericardium was recently used because it is packaged in various sizes, avoids harvest-site injury, is thin, strong and holds sutures well. The tissue is processed into an acellular matrix that allows host tissue to grow in and occupy the matrix with minimal inflammatory response. Chun *et al.* [35]

reported that 89% of men were satisfied and able to resume normal intercourse after incision and pericardial grafting. Despite this good success rate the use of cadaveric pericardium at UNC has been abandoned, replaced by the use of porcine SIS as described by Knoll [32]. The change was made partly because of the concern for prion transmission with pericardium, although this has never been conclusively shown and is largely driven by the news media. Also there were frequent problems with inconsistent pericardium graft quality on unwrapping packages. SIS, like pericardium, is processed into an acellular matrix, but is packaged more consistently in size, thickness and compliance. The authors find the use of other graft material less desirable for different reasons. PTFE, Dacron and polyethylene terephthalate grafts (synthetics) cause significant postoperative inflammation, which leads to fibrosis around the graft site. Additionally, Licht and Lewis [13] reported poor patient satisfaction in a retrospective study of 28 men with PD undergoing grafting with a synthetic material. Cadaveric dura mater has also been abandoned for concerns about slow-virus and prion transmission, although Sampaio *et al.*

[31] described good outcomes with this material. The use of venous grafts has been well documented, with good results [5,26–29]. Despite these results, venous grafts risk harvest-site infection, lymphatic leak and longer operations for harvesting and patch creation. The problems are similar with dermal grafts. Although the authors advocate the use of SIS, no material or harvested tissue has emerged as the optimum graft. Table 3 shows the recent experiences with incision and grafting procedures.

These procedures begin with ICI to stimulate an erection and assess penile curvature. For dorsal plaques the tunica is approached via a circumferential circumcision incision and subsequent degloving of the penis. Ventral plaques can usually be approached by direct incision over the plaque. A second incision lateral to the base of the penis and extending onto the scrotum may be necessary for more proximal lesions. The plaque should be easier to delineate after exposing the tunica. The neurovascular bundles, located 1–2 mm lateral to the deep dorsal vein of the penis, should be avoided. The plaque can be approached through the bed of the deep dorsal vein. Buck's fascia should be dissected off the deep dorsal vein with subsequent ligation of the vein 1 cm proximal and distal to the plaque. The vein should then be dissected free with ligation or cautery of perforating vessels. After removing the vein, Buck's fascia and the contained dorsal penile nerves are elevated. Next, a relaxing H-shaped incision is made with subsequent grafting, a technique introduced by Lue and El Sakka [36]. Larger plaques may merit complete excision, which requires relaxing incisions at the four extremities of the excised defect to ensure adequate straightening. The intestinal submucosal grafts are cut 20% larger than the measured defect to ensure adequate penile length, suturing the graft to the tunica with a running locking suture. An erection is then induced and plications made on the contralateral side of the penis if necessary for further straightening. If the penis has a large curvature after the original graft, a second incision and grafting may be used. After complete straightening, Buck's fascia is closed over the graft with a running suture. A penile block with bupivacaine is used and a light dressing applied. Also a fine suction drain is left for 12–24 h beneath the penile skin, and ice packs applied to reduce any swelling. The patient is monitored overnight and usually discharged the following morning.

Further care includes self-medication for 2–3 weeks with amyl nitrate and diazepam to limit spontaneous and nocturnal erections, and allow proper healing with improved pain control. Patients return 2–4 weeks after surgery for evaluation of their erections. Selected patients use a vacuum erection device twice daily for 10 min if they have induration or continued mild curvature at follow-up. Patients may require sildenafil or intracavernosal injections to achieve erections, especially if they have a some ED before surgery.

Reported complications include haematoma (0–4.5%), penile or glans hypoesthesia (0–16.7%), shortening (0–40%), curve recurrence (0–16.7%) and ED (0–66.7%) [5,13,26–35]. Penile or glans hypoesthesia, related to injury to the dorsal penile nerves, frequently resolves after 6–12 months, although it may be lasting. Avoiding penile shortening, associated with the Nesbit and plication procedures, is a common reason for choosing graft procedures. However, penile shortening is reported in many men undergoing grafting [5,13,27,29]. Despite this, the vast majority of the patients in these studies, i.e. 83% [29], 70% [13], 65% [27] and 60% [5] had either penile lengthening or maintenance of initial length. Also, Yurkanin *et al.* [28] reported mean penile lengthening of 2.1 cm in a recent study. Interestingly, half the patients in that study reported subjective penile shortening, despite measurements showing an actual average lengthening of >2 cm in these men. Based on these observations it is important to warn patients before surgery that shortening is possible, although lengthening or maintenance of current length is more likely.

ED is frequently associated with PD; although some patients have better rigidity of erections with grafting procedures, most will either maintain their current erections or have worsening ED. Often men who had good rigidity before surgery will require sildenafil or other assisting devices afterward; men who require assistance before surgery will almost always require it afterward, and are at increased risk of complete ED. Rates of long-term ED after surgery vary, most articles reported 0–30% [5,13,26,27,29–32,34]. The recovery of normal erectile function may take up to 6 months. Different methods for reporting the measurement of ED partly explains the large variability shown in Table 4.

PENILE PROSTHESIS

Men with PD have an increased risk of ED; presenting in their mid-fifties they frequently have comorbidities such as hypertension, hyperlipidaemia and diabetes mellitus, which contribute to this risk. Those with severe ED are unlikely to receive adequate treatment with the straightening procedures described above, as these may leave a man with a straight penis yet with inadequate erections.

Implanting a penile prosthesis, preferably an inflatable type, is a good option in men who have both PD and ED. Montorsi *et al.* [37] reported poor long-term patient satisfaction with implantation of semirigid prostheses for ED and PD. They reported good patient satisfaction in the first 3 months after implanting a semirigid prosthesis (90%), but poor satisfaction in the long-term follow-up after 5 years (48%). Patients and partners felt that the erections with the semirigid prosthesis were of poor quality, poor girth, caused partners pain and felt unnatural. Meanwhile, others [33,38–41] all reported good results with an inflatable penile prosthesis for PD, with patient satisfaction rates of 77–88%. Table 4 shows the reports with different types of prostheses over the past 10 years.

If a patient has continued curvature after implanting an inflatable prosthesis, then modelling, plaque incision/excision with or without grafting, glanuloplasty or a modified Nesbit may be used for adequate straightening. Wilson and Delk [40] first described modelling for penile straightening over three-piece prostheses in a large retrospective study involving 138 patients. Before placing the pump in the scrotum the cylinders to the pump are cross-clamped to prevent pump damage from excess back pressure. The penis is then bent for 90 s at a location opposite the plaque site. This splits plaques, often leading to an audible cracking sound. They found that modelling was effective in 118 of 138 patients, avoiding plaque incision and grafting with prosthesis placement. However, modelling increased postoperative pain and swelling, and may have been the cause of urethral perforation in four patients in the study. Despite these adverse results and complications, modelling is generally an effective, efficient and safe way to straighten the penis. In a series of 30 patients receiving a three-piece inflatable prosthesis, Carson [38] was able to use

TABLE 3 Results of tunical incision/excision and grafting in patients with PD

Ref	Graft material	N	Mean follow-up, months	Straightness %	ED %	Satisfaction %	Complications %
[26]	SV, dermal	20	19	65 straight 25 (5–15°) 10 (30° and 70°)	15 (need assist)	–	20 (1–2 cm) 5 glans hypoesthesia 5 postop plaque and pain 5 penile skin necrosis
[33]	Cadaveric pericardium	19	21.9	79.9 straight 5.2 (<30°) 15.7 (>30°)	–	73.7 satisfied 72 partner satisf.	–
[27]	SV	51	16	82.4 straight 13.7 (10–30°) 3.9 (>30°)	7.8 worse	61 excellent 31 satisfactory 8 poor	50 paraphimosis if uncircumcised 35.3 shortening, 5.9 ballooning 5.9 painful knots, 3.9 retarded ejaculation, 2 glans hypoesthesia, 2 thigh wound hypoesthesia, 2 priapism, 2 soft glans, 2 haematoma
[31]	Dura mater	40	12–72	95 good 5 (20°)	15 (10 moderate 5 severe)	–	2.5 partial foreskin necrosis 2.5 glans hypoesthesia 2.5 recurrence
[34]	Bovine pericardium	33	19.4	87.9 straight 12.1 (<15°)	0	100	none lasting
[28]	SV	22	–	59.1 straight 36.4 persistent curve, 4.5 no improvement	46 (32 need assist 14 complete) (preop in 58.3)	–	4.5 haematoma
[35]	Dermal graft	15	11	73.3 straight 26.7 min curve	66.7 need assist	78.6	13.3 glans hypoesthesia
	Cadaveric pericardium	9	6	55.6 straight 44.4 min. curve	55.6 need assist (preop in 56.5)	88.9	–
[32]	Porcine SIS	12	11	91.7 straight 8.3 (60°)	8.3 need assist	–	–
[5]	SV	50	32	80 straight 14 (≤30°) 6 (recurrence)	6 worse	88	40 penile shortening, 4 penile haematoma, 2 wound infection 2 glans ischaemia, 2 penile hypoesthesia
[29]	SV or deep dorsal vein	112	≤18 (no mean given)	96 1 (15°) 3 (30°)	12.3 worse in men potent	92	16.9 shorter penis, 10 change in penile sensation >6 month, 3.6 plaque recurrence, 2.7 leg wound infection, 2.7 penile oedema >3 month, 1.8 lymphatic leak from femoral incision, 0.9 lymphocele
[13]	Polyethylene terephthalate reinforced silicone mesh	28	12	60 straight	14	30	30 penile shortening, 21 need subsequent surgery, 14 decreased penile sensation
[30]	PTFE	16	49	56.3 straight 43.7 mild bending	0	–	Significant swelling if uncircumcised

SV, saphenous vein;

TABLE 4 Results of penile prosthesis implantation in patients with PD

Ref	Prosthesis (n)	N	Mean follow-up months,	Satisfaction	Complications
[33]	Inflatable AMS 700 CX Mentor α -1	42	21.9	88 patient (modelling) 81.8 patient (grafting) 80 partner (modelling) 72 partner (grafting)	4.8 residual curvature >30° 2.3 explanted for erosion
[38]	Inflatable AMS 700 CX	30	31.4	–	7 require glanuloplasty
[39]	Inflatable AMS 700 CX AMS 700 Ultrex	34 38	– –	– –	5.9 infection 26.3 require corporoplasty
[41]	Inflatable AMS 700 CX	33	–	79 (patient) 75 (partner)	30 with curve recurrence 30 shortening, 15 penile/scrotal pain with activation (all diabetic), 12 wound infection, 3 glans ischaemia
[40]	Inflatable AMS 700 CX (56) AMS 700 Ultrex (2) Mentor (4) Mentor α 1 (76)	138	32	–	2.9 infection 1.4 distal urethral laceration 1.4 urethral erosion
[37]	Semirigid	50 48	3 ≥60	90 (patient) 48 (patient) 40 (partner)	poor concealment, poor quality of erections Partner complaints: 17.2 unnatural feeling, 13.8 poor girth, 13.8 poor concealment, 13.8 dyspareunia

modelling in 28 patients for penile straightening, while only two required plaque incision and grafting. No patients had complications at a mean follow-up of 31.4 months. A recent report [33] found slightly higher rates of patient (88% vs 81.8%) and partner (80% vs 72%) satisfaction with modelling vs corporoplasty.

Montague *et al.* [39] compared the AMS 700 CX and 700 Ultrex (American Medical Systems, Minnetonka, MI) for patients with PD. They found that the high-pressure 700 CX inflatable cylinders, designed for girth, were better suited for penile straightening. Although the 700 Ultrex provides both girth and lengthening, 26% of patients with PD required additional corporoplasty in that study when this device was implanted. Furthermore, patients receiving the 700 Ultrex had a greater incidence of aneurysmal dilation and S-shaped deformity. These results are supported by earlier observations [40] where a high-pressure inflatable system, e.g. 700CX or Mentor α 1 was recommended to allow enough rigidity to overcome the effect of the Peyronie's plaque. Based on these findings implantation of the high-pressure inflatable prosthesis with possible modelling

is probably the most effective current procedure for patients with PD who want a prosthesis.

All patients having a prosthesis implanted, regardless of reason, should be warned of infection and device breakage during the consent procedure. Neither complication occurs at a higher rate than in patients without PD and having the prostheses. Infection frequently requires removal of the entire apparatus. Depending on when the prosthesis was placed, breakage may be fixed by replacing only part of the prosthesis or may merit replacing the entire prosthesis. Other complications include urethral perforation, possibly related to the modelling step. Montorsi *et al.* [41] found that a significant proportion of men with diabetes and PD had penile scrotal pain with activation, requiring the prosthesis to be removed in one patient.

NOVEL APPROACHES

PENILE DISASSEMBLY

Perovic and Djordjevic [42] described a new approach, penile disassembly, for treating

complex PD; of 74 patients treated surgically at their institution from November 1996 to September 2000, 46 had penile disassembly. Indications included 'severe penile deviation under the glans cap, plaque in the distal third of the corporal cavernosa with the hour-glass phenomenon, and more than one plaque at different sites.' These authors claimed that their approach avoids damage to the neurovascular bundle, allows reduction corporoplasty if the tips of the corpora cavernosa are involved, and best treats complex curvatures.

An erection is induced with prostaglandin E1 and the penis is then separated into its component parts. A circumcisional incision is made, followed by degloving of the penis. Some patients require a combined scrotal incision for large or long plaques. The urethra and the spongiosal tissue are dissected and separated from the cavernosal bodies. The corpora cavernosa are then dissected from their distal tips toward the dorsum of the penis, underneath the neurovascular bundle and Buck's fascia. The neurovascular bundle is lifted from the tunica with Buck's fascia. If the plaque is incorporated into the neurovascular bundle, the bundle is dissected through the

plaque and a portion of the plaque remains with the neurovascular bundle, while the other portion remains with the tunica albuginea. H-shaped relaxing incisions along the corpora are made in the plaque region, with one or more transverse incisions. Calcified plaques may require excision. A dermal or saphenous vein graft is placed in the corporal defect. The penis is then reassembled with the glans cap, neurovascular bundle and urethra fixed to the corpora cavernosa. Uncircumcised patients are circumcised. A Foley catheter is placed for 1 day; starting 3 weeks after surgery penile extenders and vacuum devices are used to decrease scar formation and loss of penile length.

At a mean follow-up of 27 months the penis was completely straight in 40 of 46 patients (87%). In four patients the deformity was <10° and in the remaining two <20°. Of the patients 67% were 'very satisfied', 26% 'satisfied' and only 7% 'dissatisfied'. All men with normal erections before surgery were satisfied or very satisfied. Of six patients with partial ED before surgery, four were satisfied but required ICI therapy afterward and the remaining two had a prosthesis placed. Overall, there was no infection, glans hypoesthesia, or injuries to the neurovascular bundle and urethra; 35% of patients reported transient prolonged nocturnal or painful erections. These authors provide an interesting new approach to men with complex penile curvature caused by PD.

CIRCUMFERENTIAL TUNICAL GRAFT

Lue and El Sakka [43] reported a small cohort study in which they completed circumferential tunical incisions with placement of circular venous grafts in four men with PD. Each patient had only partial erections, was unable to satisfy his partner, and felt strong dissatisfaction with his shortened penis. All men were warned that the procedure would not improve rigidity and that the goal was to improve penile length and correct the deformity.

A circumferential tunical incision is made and the penis degloved. The deep dorsal vein is isolated, resected and stored in normal saline. The paired neurovascular bundles are dissected from midline toward the corpus spongiosum. The spongiosum is then dissected off the tunica of the corpora

cavernosa. A circumferential relaxing incision is made on the tunica. A saphenous vein graft is harvested and sutured to the defect with monofilament 4-0 polyglyconate sutures. ICI with saline is used to induce an erection to assess the deformity. The penile wound is then closed and a Foley catheter placed for the next 24 h. The penis is lightly wrapped and dressings changed daily for 10 days. Patients can be discharged after 1 day with instructions for wound care and to abstain from intercourse for 6 weeks. Beginning 1 month after surgery the men used a vacuum pump daily for 30 min without constriction rings.

At 6 months, three of four patients reported an erection that was 5 cm longer, although of decreased rigidity because of an hour-glass deformity at the graft site. The other patient reported 2.5 cm longer erection without using the vacuum pump and later was lost to follow-up after leaving the country. Patients relied on the vacuum pump to achieve an erection, with one patient choosing a prosthesis 1 year after the surgery. At 18 months the remaining two patients had a penis almost 8 cm longer and regained partial rigidity, similar to that before surgery, with a resolved hour-glass deformity. After surgery all men had longer, straight penises, some psychological improvement and were satisfied. Also, all would recommend the surgery to friends. This report provides an interesting potential surgical repair in men with severe PD and shortening.

CONCLUSION

PD is a sensitive issue for patients and their partners; in one study, 77% of men with PD suffered psychologically from their condition [3]. Urologists have the potential to significantly improve the lives of these men and their partners. However, treatments must be tailored to each man. Proper treatment demands a thorough understanding of the natural history of PD, treatment options and the patient's experience with the disease. The provider must understand which medical or surgical treatments are appropriate for a man, and the discussions before surgery should include the risks and benefits. This review details the experiences of other urologists and their patients with surgical treatments for PD.

The information in Tables 1–5 should be compared with caution; problems with meta-

analyses result from different study designs. Authors use different methods for determining straightness, satisfaction and ED. Measurements are frequently subjective, by either examiner or patient; other estimates may use objective instruments. Also some reports include relatively few patients or have a sizeable proportion of men unavailable for follow-up. The results could be significantly biased from reality under these circumstances. A standard method of reporting the outcomes of surgery could optimize treatments for men with PD, by allowing more accurate comparison of the results. Reviews are still valuable for understanding the experience of other clinicians and their patients.

CONFLICT OF INTEREST

None declared.

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Abbreviations: PD, Peyronie's disease; ED, erectile dysfunction; UNC, University of North Carolina; ICI, intracavernosal injection; DUS, Doppler ultrasonography; SIS, small intestine submucosa.