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REVIEW

A critical analysis of the surgical outcomes for the treatment of Peyronie's disease

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ABBREVIATIONS

DM, diabetes mellitus;
I&G, incision and grafting;
IIEF, international index of erectile function;
PD, Peyronie's disease;
PDE5I, phosphodiesterase-5 inhibitors;

Abstract Peyronie's disease (PD) is a relatively common condition, which can impair sexual function and result in emotional and psychological distress. Despite an abundance of minimally invasive treatments, few have confirmed efficacy for improving penile curvature and function. Surgical therapies include many different techniques and are reserved for patients with stable disease of $\geqslant 12$ months' duration. We searched PubMed for all articles from 1990 to the present relating to the surgical management of PD. Preference was given to recent articles, larger series, and those comparing various techniques and/or materials. Outcomes were subsequently analysed and organised by surgical technique and the graft material used. Available surgical techniques include plication/corporoplasty procedures, incision and grafting (I&G), and placing a penile prosthesis with or without adjunctive procedures. Although several surgical algorithms have been reported, in general, plication/corporoplasty procedures are reserved for patients with adequate erectile function, simple curvatures of $<60°$, and with no deformities (hour-glass, hinge). I&G are reserved for complex curvatures of $>60°$ and those with deformities. Penile prostheses are indicated for combined erectile dysfunction and PD. Overall outcomes show high rates of improved curvature and patient satisfaction, with mildly decreased erectile function with both plication and the I&G procedure (I&G > plication) and decreases in penile length (plication > I&G). Surgical management of

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SIS, small intestinal submucosa;
DUS, Doppler ultrasonography

PD remains an excellent treatment option for patients with penile curvature precluding or impairing sexual activity. Surgical algorithms are available to assist treating clinicians in appropriately stratifying surgical candidates. Additional research is needed to identify optimal surgical techniques and materials based on patient and disease characteristics.

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Introduction

Peyronie's disease (PD) is a connective tissue disorder characterised by the presence of fibrotic plaques in the tunica albuginea of the penis. The underlying scar tissue can lead to the development of an abnormal curvature of the penis, which can result in pain, erectile dysfunction (ED), and functionally preclude sexual activity. In addition, PD might lead to severe emotional distress, including depression, anxiety and difficulties in interpersonal relationships [1].

Although PD has been a well-recognised entity for nearly 300 years, the pathophysiology remains poorly understood. The most commonly proposed mechanism for developing PD includes repeated micro/macrotrauma to the penis in susceptible individuals. Inflammation resulting from the repeated injury leads to fibroblast proliferation and abnormal collagen deposition within the tunica albuginea, which subsequently leads to reduced elasticity and contraction of the scarred tissue. The development of PD is thought to occur in two phases, i.e. an initial acute phase and a chronic phase. The initial acute phase is of 6–12 months and is characterised by pain, inflammation and disease plasticity. The chronic phase begins at >1 year, during which plaque formation and the resultant penile curvature stabilise.

The prevalence of PD is currently estimated at 3–7.1%, with autopsy studies identifying subclinical disease in up to 22% of men [2–13]. Increasing rates have been reported with some comorbidities, including diabetes mellitus (DM, 8.1%), after prostatectomy (15.9%), and combined ED/DM (20.3%) [3,11,12]. Although the incidence of PD is greatest in men aged 40–60 years, cases have been reported in other age groups, including teenagers [14].

The natural history of untreated PD remains poorly understood, with limited data available on the early phase of the disease. Among men reporting a disease onset of <12 months' duration, 30–48% report the progression of penile curvature, with 40–67% describing stable disease [15–17]. Pain similarly occurred in 40% of patients, with 6% noting persistence during the study follow-up [15]. These findings highlight the relatively small rate of disease resolution, which is in contrast to popular beliefs and earlier reports [18].

Evaluation and management

Patients presenting with PD should have a thorough history taken, to include disease onset, severity, associated symptoms, and erectile function, as well as an assessment of expectations and goals with potential treatment options. Patients with concomitant ED should undergo a standard evaluation, to include an assessment of concomitant cardiac risk factors and hormonal status.

The penis is preferably examined before and after an intracavernosal injection with a vasoactive agent, to permit an accurate assessment of disease severity (including complex curvatures, hour-glass deformities, indentations), to measure penile length, and to select appropriate management options. Penile duplex Doppler ultrasonography (DUS) before treatment further assists in the evaluation of the penile vascular status, and underlying plaque location and size. Photography is commonly used at the time of the vasoactive injection (with or without three-dimensional reconstructions) by physician staff or the patient at home, in an effort to provide a pretreatment reference point and allow for a direct comparison after therapy.

The management of PD and treatment stratification are based on several factors, including the disease characteristics, baseline erectile function, physician experience, and the patient's wishes. Patients in the acute phase of disease (6–12 months) are commonly managed with more conservative therapies, while surgery is reserved for those with stable curvatures/plaques of $\geqslant 12$ months' duration [17,19,20].

Available treatment options include oral therapies, topical/shockwave therapy, intralesional injections, and surgery. Surgical therapies can be further classified by technique, i.e. plication/corporoplasty, incision and grafting (I&G), or placing a penile prosthesis (with or without adjunctive techniques). As the current review is focused on surgical therapies for PD, a thorough discussion of the outcomes and efficacy with more conservative measures is beyond its scope.

To assist surgeons in identifying appropriate surgical candidates, several studies have identified patient factors which might increase the risk of postoperative ED [21–25]. Preoperative characteristics associated with ED include sexual function, venous leak, and age >60 years, while the duration of disease, plaque size/location, degree of curvature, presence of penile narrowing, patient

comorbidities, and preoperative phosphodiesterase-5 inhibitor (PDE5i) use are not associated with postoperative ED.

In addition to these factors, several surgical algorithms/guidelines have been established from outcome data to stratify which patients are more suited for plication, I&G, or penile prosthesis procedures [22,26,27]. Based on these guidelines, patients who are optimal candidates for plication procedures include those with curvatures of $<60°$, uniplanar curvatures with no destabilising features (hour-glass, hinge), a longer penis, and those with a $<20\%$ predicted loss of penile length. I&G procedures are reserved for those with curvatures of >60–$70°$, complex curvatures, and/or destabilising features. Patients with suboptimal penile erectile function, despite the use of PDE5i, are best treated by placing a penile prosthesis. Adjunctive procedures can be done when the prosthesis is placed, and include manual modelling, relaxing incisions, or incision(s)/excision of the plaque with or without grafting. Regardless of the technique used, the primary goal of surgery is to correct the curvature, allowing a resumption of penetrative sexual intercourse with no hindrance [28].

Before surgery patients should undergo thorough counselling and an informed-consent process, during which the goals and expectations of surgery are reviewed. Preoperative discussions are crucial because patients with PD are frequently devastated by the problem [1]. Once the patient's goals are established, it is critical for the patient to understand the possible limitations of the operation. The physician has a responsibility to explain the potential impact of therapies on penile sensation, length, erectile function, residual curvature, and the possibility of future disease occurrence and progression [29]. By following this process, the physician will set an appropriate expectation for the patient, which leads to a more satisfied outcome for the patient.

Also, given the effect of PD on decreasing penile length, patients electing to undergo surgery might additionally benefit from a pre- and/or postoperative regimen of penile lengthening using a stretching or vacuum-erection device. The use of a vacuum erection device is routinely associated with a 1–3 cm increase in penile length, regardless of which procedure was used and/or its pre- or postoperative setting [30–32].

Surgical outcomes

There are relatively few data on the surgical outcomes of patients undergoing various techniques for correcting PD. In general, available studies are predominantly retrospective, with limited patient cohorts, a short-term follow-up, and lack of standardised patient questionnaires. Few comparisons evaluating different techniques/materials are available, further limiting the conclusions that may be drawn. As such, most of the data available are of limited quality and do not permit definitive recommendations for optimal treatment strategies.

Plication/corporoplasty

In 1965, Nesbit [29] described the earliest and arguably most recognisable penile plication procedure for correcting congenital curvatures. In 1985, Pryor's group subsequently applied this procedure to 179 patients with PD [33]. The technique involves excision of an ellipsoid segment of tissue on the convex (non-diseased) surface of the penis, opposite the plaque site, with $\approx$1 mm of tissue excised for every 10° of penile curvature corrected. The ellipse is subsequently closed to effect a straightening of the penis.

The reported outcomes of the Nesbit procedure in cohorts of 40–359 patients and a follow-up of up to 7 years showed successful straightening of the penis in 86–100% of patients, with ED rates of 0–13%, and decreased penile sensation in 2–21% [34–37]. Surprisingly, and contrary to the common nomenclature that categorises penile plication as a penile shortening procedure, only 13–37% of patients experienced penile shortening [26]. Table 1 provides a summary of articles reporting the outcomes with the Nesbit plication technique [34,36–55].

Modifications to the Nesbit procedure have since been reported, including substituting a longitudinal incision closed transversely (based on the Heineke–Mikewitz technique) for the original ellipsoid tissue excision [56]. The length of incision can be estimated using Allis clamps to approximate the imbricated segment, followed by creation of an artificial erection to assess the changes in curvature. Results from the original series of 18 patients showed improved erectile function in four of six patients with preoperative ED, and satisfactory curvature permitting penetrative intercourse in 15 of the 18 [56].

Additional techniques, with small variations, include parallel incisions with plication, and plication with no incision (including the '16-dot' technique) [42,57–60]. Results from these modified techniques, with a follow-up of 24–72 months, showed successful penile straightening in 85–99% of patients, with de novo ED in 3–12%, and reduced sensation in 2–36%. Table 1 also summarises the articles reporting the outcomes with penile plication surgery.

These findings show that regardless of the technique used, plication/corporoplasty procedures result in a successful correction of curvature in $>85\%$ of patients, which is sustained at a long-term follow-up. De-novo ED occurs infrequently, and the widely varying rate of reduced sensation is of unclear significance, as it might result from variations in the dissection and techniques used.

Table 1 Outcomes of the Nesbit, plication and I&G procedures for PD.

Year	Ref.	No. of patients	Mean follow-up (months)	Overall satisfaction (%)	Penile straightening (%)	Penile shortening (%)	Sensory changes (%)	Postop ED (%)
Nesbit								
2005	[38]	40	81	N/A	87.5	100	20	5
2004	[36]	218	89	83.5	86.3	17.4	11	11.5
2003	[37]	42	84	76.2	90.5	50	21.4	2.3
1997	[39]	28	22	79	79	37	14	4
1995	[34]	359	21	N/A	82	100	N/A	1.6
1994	[40]	78	50	79	N/A	40	3.8	23
Plication								
2004	[41]	28	30	67.8	82.1	74	35.7	28
2002	[42]	124	31	96	85	41	6	6
2001	[43]	44	49	N/A	29	90	36	48
1998	[44]	29	34	62	79.3	8.3	37.9	6.8
1997	[45]	22	19.5	N/A	91	9	9	4.5
1996	[46]	28	34	82	57.1	N/A	3.5	17.9
I&G (graft material)								
2011	[47]	86 (mixed)	83	34.9	58.1	11.6	–	N/A
2009	[48]	15 (buccal)	12	93	100	0	–	0
2008	[49]	70 (vein)	41.7	87.1	75.7	N/A	–	8.6
2006	[50]	14 (fascia lata)	31	93	79	29	–	7
2005	[51]	113 (vein)	12	92.9	85.8	25.7	–	8.8
2005	[52]	26 (buccal)	38	N/A	92.3	15.4	–	7.7
2002	[53]	51 (vein)	24	92.2	82.4	35.3	–	7.8
2000	[54]	50 (vein)	32	88.0	80.0	40.0	–	6.0
1998	[55]	112 (vein)	N/A	92.0	96.4	17.0	–	11.6

I&G

I&G procedures encompass several variations in technique, including plaque incision/excision with many different grafting materials used. In general, the procedure is reserved for patients with more complex curvatures, adequate pretreatment erectile function, complex curvatures or disease characteristics (hour-glass deformities, indentation), and/or a short penis. Adverse effects associated with I&G are decreased penile sensation, urethral injury, diminished erectile function, and persistent curvatures. Reported predictors of decreased postoperative erectile function (>5 point decrease in the International Index of Erectile Function, IIEF) include preoperative curvatures of $>60°$ (odds ratio 3.1, $P < 0.01$), the specific technique used (Egydio vs. H-type incision; odds ratio 3.5, $P < 0.01$), age >55 years (odds ratio 4.7, $P < 0.001$), and baseline venous leak (odds ratio 17.2, $P < 0.001$) [23].

The procedure is most commonly applied after the use of a penile degloving incision, with the neurovascular structures dissected free (when applicable). The subsequent technique used varies depending on the surgeon's preference and experience. There are several different methods, including the H-type incision, Y-type incision, Egydio technique, or plaque excision, among others [23,61,62]. As direct comparisons between techniques are difficult due to varied patient cohorts and selection criteria, lack of randomised/prospective trials, and limited number of cases, the various outcomes will be analysed based on the grafting material used, rather than the surgical technique itself. Table 1 also provides a summary of articles reporting outcomes of the I&G technique.

Several different grafting materials have been used, with limited data available on the long-term outcomes [63]. Materials can be categorised as autografts, synthetic, or allograft/xenografts. Autografts comprise materials harvested from the patient at the time of surgery, and include dermis, tunica vaginalis, dorsal penile or saphenous vein, crura, fascia lata, rectus sheath, tunica albuginea, or buccal mucosa, while synthetic materials include numerous inert materials such as Dacron, PTFE, or silicone, among others. Allografts/xenografts are commonly used grafting materials, given their ready availability, with no need for increased surgical morbidity, a low infection rate, and ease of use. The most commonly reported materials include human cadaveric pericardium (Tutoplast, Biodynamics, Parsippany, NJ, USA) or small intestinal submucosa (SIS, Cook, Indianapolis, IN, USA).

Autologous grafts

Several series with a limited follow-up have reported the outcomes of autologous materials. One of the earliest reports of the use of dermis was from Devine and Horton in 1974 [64]. Results at the 1 year follow-up showed complete resolution of the penile curvature in 76% of

patients, with 84% maintaining sufficient erectile function for satisfactory intercourse [64]. Austoni et al. [65] subsequently reported on 418 patients at 2 years of follow-up who had a dermal graft placed, and noted a 17% rate of recurrent curvature and 20% of de novo ED.

The use of tunica vaginalis in a small series showed a 12% (three/25) recurrent curvature rate at 42 months. Despite these limited results, animal models suggested progressive increases in contracture rates over time, with 42% of grafts contracting at 12 weeks in rabbits [66,67]. The use of tunica albuginea harvested from the proximal penile corpora or contralateral region of curvature of the distal corpora has been limited by the relatively small grafts that can be harvested, and by concerns for potential future difficulties when inserting a penile prosthesis [68]. A limited follow-up in two studies showed that the penis was straightened in 84–86% of patients [69,70].

Tensor fascia lata and rectus sheath tissue have similarly been used for PD grafting, with minimal data available on outcomes. One study of 12 patients, with a mean curvature of 35° and 10 months of follow-up, showed a durable resolution of penile curvature with normal erections after placing fascia lata [71]. The use of rectus fascia also resulted in the correction of curvature in 10 of 12 patients at 4–10 months of follow-up [72]. Compared to other materials, fascial tissue has greater strength and a reduced rate of contracture, given its low metabolic requirements and high concentration of collagen.

Another material which has been used for penile grafting with PD is venous tissue from the dorsal penile or saphenous veins. El-Sakka et al. [55] reported on 112 patients undergoing incision and saphenous vein grafting, describing a 96% rate of penile straightening, 12% rate of de novo ED, and 17% of patients with penile shortening. A follow-up analysis evaluating the extent of penile shortening noted 71% with no shortening, 3.5% with <1 cm, 14% with 1–2 cm, and 11% with >2 cm [73]. These results are similar to those in other studies that reported early (12 months) resolution of curvature in 86%, 15% de novo ED, and 25% penile shortening, and with >5 years of follow-up a rate of durable penile straightening in 72%, with 22–23% experiencing ED [51,54].

In addition to its utility with urethral stricture disease, buccal mucosa has been evaluated for use in PD surgery due to its elasticity and reduced rate of contracture. One study, evaluating 26 patients at 3.2 years of follow-up, showed resolution of curvature in 92% of patients and de novo ED in 8% [52].

Synthetic grafts

Synthetic materials currently have limited popularity for PD surgery, due to their increased risk of infection, inflammation with subsequent reduced penile compliance, and overall poor outcomes. In a limited study, comparing 30 patients undergoing a modified Nesbit procedure to 28 receiving a PTFE mesh reinforced with silicone, there was improved curvature in 93% of the first group vs. 61% in the PTFE group [39]. Also, there was de novo ED in none of the Nesbit group, compared to 18% in the PTFE group, with an overall satisfaction significantly lower in the PTFE group (30% vs. 83%). Given the relatively poor outcomes, and with concerns about the increased risk of infection, the routine use of synthetic materials in PD has fallen from favour.

Allografts/xenografts

One of the most commonly used grafting materials is pericardium (bovine or cadaveric), due to its inherent strength, reported outcomes, and ready availability with no increase in surgical morbidity. Early reports of 11 patients at 14 months of follow-up showed success rate of nine, with no decrease in erectile function noted [74]. A second study of 40 patients described penile straightening in 98% of patients, with 90% achieving erections sufficiently rigid for intercourse [75]. Further reports of pericardial tissue used with the Egydio technique showed an 88% successful correction of curvature and a mean 2 cm increase in penile length among 33 patients [61]. A follow-up, multicentre study of the Egydio technique at 20 months showed that all patients were capable of penetrative intercourse, with 12% experiencing mild residual curvatures, and a mean penile length increase of 2.5 cm [76]. A contrasting study comparing a H-type incision with the Egydio technique identified the Egydio technique as a predictor of postoperative ED, highlighting the difficulty in separating individual outcomes of grafting materials by surgical technique [23].

Similar to pericardial tissue, SIS is a readily available, acellular tissue, which has been proposed to function as scaffolding for the ingrowth of host tissues. Initial reports from 12 patients, with 11 months of follow-up, identified the successful correction of curvature in 11 [77]. Subsequent reports on a combined group of 23 patients identified high rates of a recurrence of penile curvature (37–100%), graft contractures (25%), and graft complications (haematoma 26%), resulting in questions about its ongoing role in PD surgery [78,79].

Comparisons between grafting materials

Two studies have compared the outcomes after I&G with dermal, pericardial or SIS materials [47,80]. Kovac et al. [80] reported on a combined group of 36 patients at 22 months of follow-up, and noted resolution of curvature in all the pericardial group, 77% of SIS, and 60% of the dermal group, with preserved erectile rigidity in 39%, 77% and 60%, respectively. Chung et al. [47] reported on a similar cohort of 86 patients at >5 years

of follow-up. There was recurrent curvature in 50% of the dermal group, 24% of SIS, and 13% of the pericardial group, with all groups having penile shortening (17–29%) and decreased erectile function (the IIEF score decreased by 3–8 points). Notably, to our knowledge, no study has compared the outcomes of I&G with a control group; as such, the true rate of decreased erectile function and loss of penile length from surgery are difficult to separate from the natural progression of PD. Based on these data, no specific grafting material has shown consistent superiority, with the choice of graft largely left to the surgeon's judgement and preference.

Penile prostheses

Placing a penile prosthesis for the treatment of PD is reserved for patients with inadequate preoperative erectile function, refractory to PDE5i. The exact indications and parameters of erectile function that must be met before inserting a prosthesis are not well established. Some authors recommend a penile prosthesis with any degree of preoperative venous leak or a peak systolic velocity of <35 cm/s on penile duplex DUS, IIEF scores of <15 (on PDE5i), or self-reporting of inadequate penile rigidity for penetration (including with PDE5i) [22,23,61,76].

The procedure for placing a penile prosthesis in patients with PD is similar to that for primary prosthesis implantation. There is some increased difficulty on occasion with corporal dilatation secondary to plaque-associated fibrosis. Although the long-term outcomes are generally limited for a penile prosthesis in patients with PD, three studies with follow-up periods of 42 to >60 months reporting on 493 cases in all, noted prosthesis malfunction rates of 8–12.5% and infection rates of 1–4.8% [81–83].

Overall improvements in curvature after implanting a penile prosthesis are excellent, with 0–5% of patients having residual curvatures of >20–$30°$ and 70–88% reporting satisfaction [82,84–87]. Although most cases achieve straightening with implantation of the device and manual modelling alone, 29–40% require adjunctive techniques, including incisions with or without grafting. When analysed by type of adjunctive procedure, Levine et al. [82] reported incision of the plaque alone in 4% of patients, with incision and grafting required in an additional 12%. The overall satisfaction was similarly high, and reported among 79–96% of patients and 75–77% of partners, with 91–100% able to achieve intercourse after the procedure [84].

Comparisons of the outcome of the penile prosthesis between PD and non-PD patients show contradictory findings. Mechanical failure rates are significantly higher in one study (PD patients 33% vs. 4% non-PD) and equivalent in another (PD patients 12.5% vs. 12.4% non-PD) [81,88]. Similarly, an early comparison between types of device implanted reported an increased risk of device failure with the American Medical Systems (AMS, Minnetonka, MN) 700 CX prostheses compared to the Mentor Alpha-1 model [81]. As this trial was done before the addition of a Parylene coating with the AMS devices, a subsequent study showed contrasting findings of 91% vs. 87% for the 5 year survival rates with the AMS 700 CX (88 patients) compared to the Coloplast Titan™ (50 patients). This suggests an excellent mechanical reliability, while confirming findings consistent with contemporary results of patients without PD who have a penile prosthesis implanted [89,90].

Beyond correcting curvature at the time of implanting a penile prosthesis, several authors reported on techniques to increase overall penile length. Sansalone et al. [91] recently published findings from 23 patients undergoing circumferential grafting of the corpora, followed by insertion of a penile prosthesis. At 22 months of follow-up there was a 2.8 cm increase in length, 15% reported persistent curvatures of $<15°$, 20% had decreased glans sensitivity, all were able to participate in penetrative intercourse, and 90% were satisfied with the results. An additional lengthening technique consisting of offset hemi-circumferential incisions of the corpora ('sliding technique') was also recently described in three patients [92]. Using SIS grafting materials at a follow-up of 13 months, a 3.2 cm increase was achieved. All patients reported maintaining glanular sensitivity and the ability to resume intercourse. Given their recent introduction, longer-term outcomes and external validation are required before routine implementation of these adjunctive techniques.

Comparisons of surgical techniques

Several studies have compared the outcomes of penile plication, I&G, and penile prosthesis insertion for the treatment of PD. Taylor et al. [58] compared 61 patients undergoing penile plication with 81 who received partial plaque excision with cadaveric pericardial fascia grafting. The mean follow-up was 72 and 58 months, respectively. Patients with simple curvatures of $<60°$ with no hour-glass or hinge deformities were stratified to receive plication. The results for plication and I&G, respectively, showed residual curvatures $<30°$ in 93% vs. 91%, maintained rigidity in 81% vs. 68%, de novo ED in 10% vs. 21%, and increased length of 0.6 vs. 0.2 cm. A subsequent study of a combined group of 218 patients at 84–91 months of follow-up reported a statistically insignificant increased rate of ED among I&G patients (21% vs. 10%, $P = 0.12$). Preoperative comorbidities and penile duplex Doppler US results were not found to be predictive of postoperative erectile function [25].

Mulhall et al. [22] also reported on 62 patients with PD undergoing penile corporoplasty, I&G, or insertion of a penile prosthesis. Patients with simple, uniplanar curvatures of $\leqslant 60°$ and a predicted penile length loss of $< 20\%$ of total penile length were stratified to undergo a modified corporoplasty with parallel tunical incisions opposite the plaque, with the central tunical island invaginated. There was a slight postoperative increase in the IIEF scores for the corporoplasty group (24 before to 26 after). There was a statistically significant decrease in the I&G group (23 before, to 18.5). Similarly, the postoperative IIEF satisfaction domain scores were higher for the corporoplasty and penile prosthesis groups, but lower for the I&G group. The authors subsequently concluded that not all patients with combined PD/ED would require a penile prosthesis, and that I&G was a poor option for men with PD/ED.

An additional study by Kadioglu et al. [49] compared the outcomes of 15 patients undergoing penile plication, 75 with incision and venous grafting, and 60 having a penile prosthesis inserted. Patients with simple curvatures of $< 60°$ with no hinge or hour-glass deformities, and satisfactory erectile function/penile length, were treated with penile plication, while those with impaired erectile function had a penile prosthesis inserted. There was an improved curvature in 76% (I&G) vs. 98% (prosthesis). There was a recurrence of curvature in 13%, 18% and 2% of the plication, I&G and prosthesis groups, respectively. De-novo ED was only reported in the I&G group, at 9%.

Recently, the European Association of Urology released a summary guidelines statement [26]. Findings were reported on several studies in patients with PD, evaluating the outcomes of the Nesbit, plication and I&G procedures, respectively, showing rates of penile shortening (5–31%, 41–90%, 0–40%), penile straightening (79–100%, 58–100%, 74–100%), persistent/recurrent curvature (4–27%, 8–11%, 0–17%), postoperative ED (0–13%, 0–23%, 0–15%), and penile hypoesthesia (2–21%, 0–21%, and 0–17%). The composite of all of the above studies highlights the significant variability of outcomes with the various surgical procedures, and supports the role for treatment algorithms in selecting appropriate surgical candidates.

Summary

PD is a prevalent disorder which results in significant physical and psychological impairments among affected patients. Despite earlier reports of high rates of spontaneous resolution, the untreated natural history of PD shows minimal improvement or progression of disease in most patients. Few experience a spontaneous resolution of the symptoms.

Despite its long-standing historical recognition, there are no curative, and few minimally invasive, effective treatments. Surgical therapies are typically reserved for patients with stable curvatures of at least 12 months' duration, those with curvatures precluding/impairing penetrative sexual intercourse, or those seeking a definitive therapy. Currently available surgical therapies include plication/corporoplasty, I&G, and insertion of a penile prosthesis with or without adjunctive straightening techniques (manual modelling, plaque incision with or without grafting).

Several surgical algorithms have been reported to assist surgeons in stratifying patients based on disease characteristics. Patients with simple, uniplanar curvatures of $< 60°$, with no deformities (hour-glass, hinge), and with satisfactory preoperative erectile function, might be best treated with penile plication/corporoplasty procedures, while those with more complex curvatures of $> 60°$ with deformities and preserved erectile function might be better suited for I&G procedures. Patients with poor erectile function refractory to PDE5i are appropriate candidates for a penile prosthesis. Available grafts include different types of autologous, synthetic, or allogeneic/xenogeneic materials.

Although there are limited data available that compare the outcomes of the various surgical procedures and grafting materials, results from patients stratified by the above criteria show a correction of curvature with all procedures in most patients, mildly decreased erectile function with both plication and I&G procedures (I&G > plication), and penile shortening in both plication and I&G procedures (plication > I&G). Adjunctive operative and postoperative treatments have been reported to increase penile length with a minimal increase in morbidity.

Patients having a surgical correction of PD should undergo a thorough discussion of the management options, including the goals of therapy, and appropriate postoperative expectations. Ongoing research is required to identify optimal surgical techniques, grafting materials and assessment of the psychological impact of treatment.

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