The Management of Peyronie’s Disease: Evidence-based 2010 Guidelines

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ABSTRACT

Introduction. The field of Peyronie’s disease is evolving and there is need for a state-of-the-art information in this area.

Aim. To develop an evidence-based state-of-the-art consensus report on the management of Peyronie’s disease.

Methods. To provide state-of-the-art knowledge regarding the prevalence, etiology, medical and surgical management of Peyronie’s Disease, representing the opinion of leading experts developed in a consensus process over a 2-year period.

Main Outcome Measures. Expert opinion was based on grading of evidence-based medical literature, widespread internal committee discussion, public presentation, and debate.


Key Words. Peyronie’s Disease; Guidelines; Surgery; Pathology

Introduction

Peyronie’s disease (PD) is currently considered a wound healing disorder that presents with a fibrous inelastic scar of the tunica albuginea that is currently believed to occur in the genetically susceptible individuals following trauma to the penis. It is characterized by the development of a palpable scar, which in the erect state causes a variety of deformities, including curvature, shortening, narrowing, and hinge effect. In the early phase there is often an inflammatory component that causes pain. PD is also frequently associated with erectile dysfunction (ED), and a variety of other comorbid disorders, including diabetes, hypertension, dyslipidemia, and low testosterone. The quality of life of both the patient and partner may be significantly affected, with an increased risk of depression, low self-esteem, and relationship difficulties being common [1–3]. Overall, approximately 30% of patients will have diabetes, which has been found to be associated with advanced curvatures and vasculogenic ED [4,5]. Two thirds of patients with PD are likely to have risk factors for arterial disease and therefore worsening long-term erectile function [5]. PD is a progressive disorder with up to 48% of men having disease progression if left untreated [6]. In most cases, PD may be divided into an acute inflammatory phase and a chronic phase. During the former, there may be penile pain and curvature progression although the pain typically resolves spontaneously within 6–18 months from onset in most patients [6].
PD—OVERVIEW GRADE A
PD is a physically and psychologically devastating problem manifest by a fibrous inelastic scar of the tunica albuginea, which results in a penile deformity (e.g., bending, narrowing, hinging, shortening), as well as painful erections, all of which may lead to difficulty with intromission. There are relatively few high-level evidence-based therapeutic studies.

PREVALENCE OF PD GRADE B
Multiple demographic studies have been performed worldwide indicating a prevalence rate of 3–9% in adult men. Therefore, PD is not a rare disorder.

NATURAL HISTORY GRADE C
The natural history of PD has been evaluated in only a few level 2 and 3 studies indicating that spontaneous deformity resolution is not common and remains less than 13%.

Patient Evaluation
The diagnosis of PD is usually apparent from the patient history and penile examination. The main points to gather from the history are whether the disease is still active, the nature of the curvature and the presence of ED. Patients with short disease duration (<12 months), penile pain, or a recent change in penile deformity are still likely to have active inflammatory disease and therefore are not surgical candidates and would be more likely to benefit from medical therapy. Penile pain may be persistent in the inflammatory stage of the disease but is usually only present during erection. The pain is not usually severe in nature but may interfere with sexual function although spontaneous improvement usually occurs as the inflammation settles within 6 months and almost all men will experience pain resolution by 18 months (94% of 246 men treated conservatively) [6–9].

All the patients have either a well defined plaque or an area of induration that is palpable on physical examination, even though patients may be unaware of it [8]. The plaque is located on the dorsal surface of the penis in two thirds of patients with a corresponding dorsal penile deformity [9]. Lateral and ventral sited plaques are not as common but result in more coital difficulties as there is a greater deviation from the natural coital angle. Multiple plaques located on opposite sides of the penis or plaques appearing in the septum may cause penile shortening with or without a penile deformity [10]. The consistency of the plaque, be it soft, tender, calcified, or ossified should be noted as this may act as a guide to management. Calcification may occur at initial presentation or develop over time. It appears that calcification is not a manifestation of a more mature plaque as previously thought. Rather it may represent a different genetic subtype of PD [11].

An assessment of the curvature on erection is best made by an intracavernosal injection of a vasoactive agent; a home photograph or a vacuum assisted erection test can be also useful in the diagnosis [12]. This also allows complex curvatures to be assessed and will aid in the decision for the type of treatment best suited to the individual. The severe emotional distress that occurs is, in part, a result of the deformity, but mainly because of the penile shortening that occurs in almost all patients with up to 50% of them being clinically depressed. It is imperative therefore that the stretched penile length is measured preoperatively so that the patients realize that the length loss postoperatively is mainly a result of the disease itself and not to the surgery [13–15]. ED associated with PD has been reported in up to 58% of men [2,5]. It is not uncommon for unsuspected PD to be diagnosed at the time of investigation of their ED [16,17]. Since ED is a common finding in patients with PD [18]. A detailed history of any arterial risk factors for ED should be noted and an assessment of erectile function best made by the validated International Index of Erectile Function-5 questionnaire [19]. A PD-specific questionnaire is in development and should aid in the assessment of the man with PD and may prove useful in evaluating quality of like-related changes following treatment.

Investigations in PD
Ultrasound is used to identify the site and consistency of the plaque and is a useful tool in the clinical trial setting to assess penile vascular bloodflow parameters. It can also determine the extent of plaque calcification as those men with extensive calcification have historically been noted to not respond well to nonsurgical therapies. Extensive calcification appears to be a primary indication for surgical correction as these plaques do not respond to medical therapy. It is a minimally-invasive technique that is more accurate than X-ray, CT scan, or MRI [20]. A vascular assessment should be performed in all patients with ED as well as those undergoing surgery and is best done using duplex...
ultrasound [21]. The results of this investigation can often show vascular disease in patients who report normal potency which may influence the subsequent management [22].

**Clinical Diagnosis—Overview**

There is no international standard for evaluation or reporting on treatment outcomes for PD. A detailed history should be obtained focusing on onset, duration, pain, and deformity.

**Clinical Diagnosis—Objective Assessment**

Suggested objective measures include: measuring stretched penile length, and describing plaque location (dorsal, ventral, septal, proximal, distal, etc.)

**Clinical Diagnosis—Plaque Size**

Plaque measurement is inaccurate by any modality, as well as operator dependent and therefore is not a reliable assessment for treatment response.

**Clinical Diagnosis—Duplex Ultrasound**

Dynamic duplex ultrasound provides assessment of plaque calcification, vascular flow parameters, and objective measures of deformity. It is a useful but not necessary test.

Epidemiology: Prevalence and Comorbidities

Recent studies suggest a prevalence of PD in the population that can reach up to 9% [22–33], much higher than initially thought.

The mean age of onset of the condition in these studies was 55–60 years, and penile curvature was present in over 80% of patients whereas painful erection was reported by over half of them [3,31,34–42].

History of a penile trauma has been reported by 5–13% of patients with PD.

Some studies have revealed a significant association with ED in comparison to the non-PD population [35,38,39,41]. The association with Dupuytren’s disease was only investigated since 1999 in two studies, where it was shown to be highly significant in the older population [3], and affecting 39% of PD patients vs. only 1.2% in the controls [42].

Epidemiological studies showed that PD is significantly associated with diabetes [3,5,31,32,34,37,41–43]. Some of these reports provided data supporting a significant association of PD with obesity [34,38,43], hypertension [3,5,36,41], hyperlipidemia [3,5,33,34,37,38], smoking [32,34,37,38,42,43], and pelvic surgery [42].

**Common Comorbidities**

Multiple comorbidities have been identified, including ED, hypertension, diabetes mellitus, hyperlipidemia, low testosterone, and Dupuytren’s disease. It remains unclear whether any of these contribute to the development of PD.

Etiology and Histopathology

A widely accepted hypothesis on the etiology of the PD plaque is that it originates from trauma or microtrauma to the erect penis [44–55] in patients with genetic predisposition to form localized fibrosis as a response to trauma [56–62]. The main pathological process is tissue fibrosis with disorganization of elastic fibers, combined in most cases with fibrin accumulation and different degrees of inflammation [48,50,63–75]. Consequently, spontaneous regression is a rare event [5,42].

Recent studies on an animal model suggest that transforming growth factor beta (TGFβ1) [63,72,76–86] and myofibroblasts [44,45,72–74,81–83,87–95] play an important role in the formation of PD plaques. TGFβ1 is also found in the human PD plaque and is the main profibrotic factor in multiple tissues [84], while myofibroblasts are a common feature in most tissue fibrosis and in abnormal wound healing [96], and their persistence by the inhibition of programmed cell death leads to scar formation [51]. Moreover, the tunica albuginea is known to contain pluripotent stem cells that are potentially able to differentiate into myofibroblasts, smooth muscle cells, and osteoblasts, and in a paracrine fashion to modulate the differentiation of a multipotent cell line into osteoblasts and myofibroblasts [11,97–109]. The presence of stem cells in the normal tunica albuginea may explain the fibrotic and osteogenic progression of the PD plaque upon the release of cytokines following microtrauma to the penis that would stimulate this cell lineage commitment.
PD—PATHOGENESIS GRADE C
PD is a wound healing disorder occurring in a presumed genetically susceptible individual whose tunica albuginea responds inappropriately to an inciting event (i.e., trauma) with a proliferative, fibrotic reaction resulting in an exuberant, inelastic scar. A closer understanding of the etiopathophysiology is not yet established.

Nonsurgical Management of PD
As a result of the lack of a clear understanding of the etiopathophysiology, a cure has not been found. Therefore, a variety of treatment options have been used. The most current therapies are reviewed. The value of many published reports has been questioned as most were not well controlled, often had a small number of subjects in various phases of stability and with limited reports on objective measures of deformity change. Studies focus on reduction of pain that appears to resolve with time untreated, and reduction of plaque size, which has never been found to correlate with curvature improvement. In the opinion of the authors reduction of erect penile deformity (i.e., curve, narrowing, shortening) is the most critical outcome measure.

CANDIDATES FOR NONSURGICAL THERAPY GRADE C
Men with early phase disease (i.e., <12 months induration) manifest by unstable or progressive deformity and painful erections as well as those not psychologically ready or interested in surgery may be considered candidates for nonsurgical therapy.

NONSURGICAL TREATMENT OVERVIEW GRADE C
Nonsurgical treatment has limited evidence of benefit, but multiple reports of deformity stabilization or reduction makes it reasonable to offer EMDA, and/or intralesional injection of verapamil or interferon, and/or traction therapy.

Oral Therapy
Potassium Para-Aminobenzoate
Although initial studies [110,111] showed only a minimal improvement in symptoms of PD with the use of potassium paraminobenzoate, more recent articles showed a significant reduction in plaque size but no change in pain or improvement of the curvature [112]. These results, although encouraging, will need to be confirmed in future studies.

Vitamin E
Vitamin E is the most common nonsurgical therapy prescribed by urologists for treating PD [113]. However, recent double-blind, placebo controlled, randomized studies showed nonsignificant improvement in pain, curvature, and plaque size, when compared with placebo [114,115].

Tamoxifen
In 1992, Ralph et al. confirmed that the daily administration of Tamoxifen 20 mg twice daily can induce significant improvement in penile pain, curvature, and plaque size in the early stages of the disease [116]. However, these encouraging results have not been confirmed by recent studies [117].

Colchicine
Although initial studies showed that colchicine might be also effective in the early phase of the disease according to the finding of two recent studies [118,119], recent series have showed that colchicine is no better than placebo [120].

Vitamin E and Colchicine
Although the administration of vitamin E and colchicine in isolation has been proved to be ineffective, a recent double-blind randomized study has showed that the administration of a combination of vitamin E and colchicine can induce significant improvement in plaque size, curvature, and pain during the initial phase of PD [121].

Acetyl Esters of Carnitine
Although initial studies fail to demonstrate any efficacy of this combination in the treatment of PD, recent data suggest that propionyl-l-carnitine and verapamil are effective in terms of plaque size reduction, pain, and penile curvature [115,122,123].

Pentoxifylline
Increased levels of nitric oxide levels may be effective in preventing progression of PD or reversing its fibrosis as described by Brant et al. [124]. Further studies will be required to confirm these findings.

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**ORAL THERAPY GRADE B**
There is evidence that there is no benefit with respect to deformity reduction with any oral therapy, including Vitamin E, potassium aminobenzoate, colchicine, tamoxifen, and carnitine.

**Intralesional Injections**

**Steroids**
Although six studies using injectable corticosteroids for the treatment of PD showed positive outcomes from treatment, the authors believe that the therapeutic effects were because of the mechanical effects of the injection and not to the drug action itself [125–131].

**Collagenase**
Although the prospective, randomized, placebo-controlled study of Gelbard failed to demonstrate any clinical benefit with the use of intralesional injections of collagenase [104], a recent study has reported significant decreases in deviation angle, in plaque width and length [132].

**Verapamil**
In vitro studies verapamil has been shown to interfere with Peyronie’s plaque derived fibroblast cellular proliferation and Levine et al. reported that intralesional verapamil injection induces a significant reduction in penile curvature [133–136]. These encouraging results have been confirmed by two subsequent studies, while one failed to demonstrate any effectiveness of this treatment [137–139].

Although large scale, placebo-controlled trials have not been conducted, intralesional Verapamil injections could be recommended for the treatment of noncalcified acute or chronic plaques to stabilize disease progression or possibly reduce penile deformity.

**Interferon**
Hellstrom and associates conducted a singleblind, multicenter, placebo-controlled parallel study that showed that intralesional interferon alpha-2B may be beneficial for men with PD [140]. These findings offer the largest and best-controlled trial of intralesional therapy for PD, as well as supports its use and demonstrates the lack of clinical benefit following intralesional injection of saline. It is significantly more costly than verapamil and has been associated with flu-like side effects. However, a recent study failed to demonstrate any efficacy of intralesional injection [141].

**TREATMENT—INJECTION THERAPY**
Intralesional injection may be used with the following:

- **Steroids**—no objective measures of therapeutic benefit. **GRADE D**
- **Verapamil**—appears to make scientific sense but no large scale placebo-controlled trials. **GRADE C**
- **Collagenase**—Several small noncontrolled trials showed limited benefit. It is currently being studied in a phase 2b trial. **GRADE D**

**Other Noninvasive Therapy**

**ESWL**
Although initial studies failed to demonstrate any efficacy of extracorporeal shock wave therapy (ESWT) for the treatment of PD [142–144], more recent studies suggest a possible role of ESWL in the reduction of pain [145–147].

**TREATMENT—SHOCK WAVE THERAPY GRADE B**
There is evidence that ESWT does not improve PD-related deformity.

**Iontophoresis**
Although two studies proved the efficacy of iontophoresis using dexamethasone, verapamil, and lidocaine in terms of reductions of pain, plaque size, and curvature [148,149], a recent series of Greenstein and Levine suggests that the only role for iontophoresis is for the improvement of pain [150].

**TREATMENT—TOPICAL VERAPAMIL GRADE D**
As there are no independent controlled trials and no evidence of adequate levels within the tunica albuginea, no recommendation is possible for topical Verapamil.

**TREATMENT—TOPICAL ENERGY–IONTOPHORESIS GRADE C**
Several controlled trials had evidence of reduced deformity following iontophoresis treatment using verapamil and dexamethasone.
**Penile Traction Devices**

It is well-documented that gradual expansion of tissue by traction, also known as mechanotransduction, results in the formation of new connective tissue by cellular proliferation in several tissue models including bone, muscle, and Dupuytren's scar [151–153]. However, penile traction has proved to have insignificant role in the management of PD [154,155].

**TREATMENT—TRACTION THERAPY GRADE C**

Early evidence from two small noncontrolled prospective trials have reported a reduction of deformity and increased penile length with traction therapy.

**Surgical Treatment**

**Indications**

Surgery is indicated when the curvature impedes adequate sexual penetration or there is an associated ED that fails to respond to medical treatment and should be offered only once the disease has stabilized. In addition, patients who have extensive plaque calcification are typically best treated with surgery, as nonsurgical approaches have not been shown to be beneficial in this circumstance. Lastly, the patient who wants the most rapid and reliable result should select a surgical approach [26,156] (Table 1).

Many of these men are depressed, have marked reduction of self-esteem, and oftentimes have unattainable expectations regarding the outcome from surgical reconstruction [15]. Therefore, a detailed discussion on persistent or recurrent curvature should be initiated with the accepted goal of making the patient “functionally straight,” which is loosely defined as a curvature of less than 20° [157]. Loss of length is most likely to occur with plication procedures, particularly in those with ventral curvature [158]. In addition, there may be diminished rigidity, which has been shown to occur regardless of the surgical approach. Clearly, those who have suboptimal preoperative rigidity have a higher risk of postoperative ED. The incision and grafting technique appears to increase the risk of postoperative ED, and therefore men who have borderline to inadequate erections preoperatively, which do not respond to pharmacological therapy, should avoid grafting procedures or be prepared to need subsequent penile prosthesis implantation [159]. Lastly, there is a risk of decreased sexual sensation. This has been infrequently reported in the published literature, but it seems for the most part it rarely compromises orgasm and ejaculation. Surgical algorithms have been published to guide the choice of surgical approach ([160], Table 2).

Two main preoperative factors contribute to this decision, including penile rigidity and severity of deformity [161–163]. When rigidity is adequate, with or without drug assistance, two approaches have been suggested including tunica plication techniques, which are recommended when there is a simple curvature of less than 60–70°, and no hourglass deformity, and when the presumed loss of length caused by the plication will be less than 20% of total erect length. For men who have more complex curvature greater than 60°, and/or a destabilizing hinge or hourglass effect then plaque incision, or partial plaque excision and grafting is preferred. It is important to stress that this approach is recommended for men who have good quality, preoperative erections.

**SURGICAL TREATMENT GRADE C**

Surgery remains the gold standard for correcting erect penile deformity in the man with stable disease.

**INDICATIONS FOR SURGICAL RECONSTRUCTION GRADE C**

Surgical reconstruction is indicated in the man who has stable disease for > 6 months, painless deformity, compromised,
or inability to engage in coitus secondary to deformity and/or inadequate rigidity, when there is extensive plaque calcification, and for the man who desires the most rapid and reliable result.

SURGERY—PREOPERATIVE CONSENT GRADE D

The preoperative consent is critical to set proper outcome expectations for the patient. It is imperative to have a discussion on the risks of persistent or recurrent curvature, loss of erect length, diminished rigidity, and decreased sexual sensation.

SURGICAL ALGORITHM GRADE C

Several surgical algorithms have been published with general agreement that for men with adequate preoperative rigidity, some form of tunica plication procedure is best for those with curvature less than 60° and with no hour-glass deformity resulting in a hinge effect. For those with more severe deformity (>60° and/or hourglass) and good preoperative rigidity, incision or partial excision and grafting is recommended.

Surgical Approaches

Plication Procedures

This review of surgical approaches begins with the plication procedures, which are designed to shorten the longer side of the penis. If the curvature is in a dorsal direction, the plaque causes shortening of the dorsal aspect, and therefore to correct the curvature with plication, the ventral aspect is shortened. This approach is based upon the Nesbit procedure where an erection is created and a wedge of tunica is excised from the convex (longer) side, then the edges are reaproximated to create the shortening effect [164]. Currently, there are many variations of the plication procedure, which include procedures where a portion of the tunica is not excised, but instead plicated such as the Essed-Schroeder technique [165]. The Yachia technique utilizes the Heinke-Mikowitz principle where a vertical incision is closed transversely so as to shorten the convex side of the penis [166]. The tunica albuginea plication technique corrects the deformity by plicating a series of paired incisions into the tunica without exposing the underlying cavernosal tissue [157]. The 16-dot procedure utilizes an extended Lembert type of suturing technique [167]. In this procedure, a dorsal curve is corrected with sutures placed into the tunic on both sides of the urethra, then progressively tied down so as to create shortening and straightening. There is no tunica incision or tissue excision performed; therefore, the correction of deformity relies upon the nonabsorbable sutures. All these procedures appear to adequately straighten the penis with little risk of compromising erectile function. It is critical that during the performance of any straightening procedure the surgeon is able to induce an erection, usually by needle injection of saline by pump or syringe (Table 3). The advantages to the plication approach are that they are simple, minimally invasive, and tend to preserve potency in most patients. The disadvantages are that they can result in penile shortening, which has been shown to be exacerbated by correction of curvature greater than 60°, and/or a ventral curvature where dorsal plication is necessary [158]. Lastly, plication procedures may worsen an existing hour-glass or hinge effect, particularly if large plications are used.

Table 3  Peyronie’s Disease published reports—plication procedures

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Patient #</th>
<th>Procedure</th>
<th>% straight</th>
<th>% with ED</th>
<th>% reduced sensation</th>
<th>Follow up (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ralph [164]</td>
<td>1995</td>
<td>359</td>
<td>Nesbit</td>
<td>89</td>
<td>2</td>
<td>2</td>
<td>Not reported</td>
</tr>
<tr>
<td>Brock [168]</td>
<td>2004</td>
<td>23</td>
<td>Minimally invasive plaque excision</td>
<td>91</td>
<td>Not reported</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>Paitch [169]</td>
<td>1999</td>
<td>183</td>
<td>Modified corporoplasty</td>
<td>89</td>
<td>4</td>
<td>Not reported</td>
<td>24.1</td>
</tr>
<tr>
<td>Rolle [170]</td>
<td>2005</td>
<td>50</td>
<td>Nesbit</td>
<td>100</td>
<td>0</td>
<td>Not reported</td>
<td>11</td>
</tr>
<tr>
<td>Savoca [171]</td>
<td>2004</td>
<td>218</td>
<td>Nesbit</td>
<td>86.3</td>
<td>13</td>
<td>Not reported</td>
<td>89</td>
</tr>
<tr>
<td>Syed [172]</td>
<td>2003</td>
<td>50</td>
<td>Nesbit</td>
<td>90</td>
<td>Not reported</td>
<td>21</td>
<td>84</td>
</tr>
<tr>
<td>Greenfield [158]</td>
<td>2006</td>
<td>68</td>
<td>Tunica albuginea placation</td>
<td>99</td>
<td>7.3</td>
<td>4</td>
<td>29</td>
</tr>
<tr>
<td>Gholami [167]</td>
<td>2002</td>
<td>132</td>
<td>16 dot placation</td>
<td>85</td>
<td>3</td>
<td>Not reported</td>
<td>31</td>
</tr>
<tr>
<td>Taylor [157]</td>
<td>2008</td>
<td>90</td>
<td>Tunica placation</td>
<td>93</td>
<td>12</td>
<td>36</td>
<td>72</td>
</tr>
</tbody>
</table>
There is no evidence that one surgical approach provides better outcomes over another, but curvature correction can be expected with low risk of new ED or sensory change.

Incision or Partial Excision and Grafting Techniques
Surgical grafting techniques include plaque incision or partial excision. Historically, total plaque excision was designed to “remove the diseased tunica,” but this causes an unacceptably high rate of postoperative ED. This has been suggested to occur as a result of a compromised veno-occlusive mechanism, because of the changes in the relationship between the cavernosal tissue and the overlying tunic or graft [173]. Therefore, minimizing the excision or making simple releasing incisions have been recommended so a smaller graft may be used [174].

The search for the ideal graft continues. As of this time, no ideal graft has been identified, which would take reliably, not contract, be resistant to infection and preserve erectile capacity [175] (Table 4).

Currently, it appears that the nature of the graft is less likely the determining factor with respect to postoperative ED. On the other hand, it is most likely a result of patient selection with respect to preoperative erectile status and operative technique [159]. Larger grafts, men older than 60 years old, and those with ventral grafting also appear to have a higher risk of postoperative ED [162,175–177]. A variety of autologous grafts have been used including dermis, tunica vaginalis, temporalis fascia, buccal mucosa, and fascia lata [178]. The most frequently used autologous graft currently in use is saphenous vein, which requires a separate incision to harvest, adding a risk of local side effects, and longer operating time with a second incision to heal. Synthetic grafts were used historically, including polyester and polytetrafluoroethylene, but these have not been met with enthusiasm because of the increased risk of infection, an unnatural feel and may have the potential for more local inflammation and fibrosis [179]. The modern era of grafts include off-the-shelf processed human cadaveric tissue or xenografts. These are felt to be advantageous because they can reduce operating time substantially, they appear to have similar midterm outcome results as compared with autologous grafts, and there is no harvest morbidity. These grafts include human and bovine pericardium, porcine small intestinal submucosa, and porcine and human dermis. All these grafts undergo an extensive processing to clear the tissue of cells, bacteria, viruses, and presumably prions. As of this time there has been no report of host viral infection secondary to processed allograft or xenograft implantation. The operative procedure is done essentially the same for all grafting techniques—an artificial erection is created demonstrating the curvature and the penis is typically degloved using a circumcising incision allowing exposure of the entire shaft of the penis. In the area of maximum curvature, Buck’s fascia containing the neurovascular bundle is elevated, either from a pair of parallel incisions lateral to the urethral ridge allowing elevation of Buck’s fascia dorsally, or by coming through the bed of the deep dorsal vein. It is felt that the deep dorsal vein approach may not offer adequate lateral exposure, which would be especially important for patients who have severe lateral indentation or hour-glass deformity. The elevation process is best performed with loupe magnification and bi-polar electrocautery so as to reduce the likelihood of injury to the neurovascular tissues. Once Buck’s fascia is properly elevated an artificial erection is recreated demonstrating the area of maximum deformity. Surgeons differ in their approach as to whether a simple modified H-like incision should be made to the area of maximum curvature or whether partial plaque excision is recommended, particularly when there is significant indentation and/or calcification. Regardless, the goal is to remove as little plaque as possible, but to allow proper correction of the deformity by expanding the tunic in both girth and length. Edygio has championed the geometric principle approach to graft sizing [180].
This technique has proven useful in his hands, but a recent report suggested a higher risk of postoperative ED [177]. Once the graft is positioned, Buck’s fascia is reapproximated to provide support and a vascularized cover over the graft.

**Postoperative Care and Rehabilitation**

Following surgery, postoperative rehabilitation is recommended to enhance recovery of erectile function. Massage and stretch therapy, is performed by grasping the glans penis and pulling it gently and repeatedly away from the body while also gently massaging the graft area. This is initiated 2 weeks after surgery and performed twice a day for 4 weeks. It is advised that the patient’s partner get involved in the rehabilitation process to lessen the anxiety associated with the resumption of sexual activity for both partners. Bedtime phosphodiesterase inhibitors have been recommended to begin 7–10 days after surgery and to be maintained for 6 weeks, in order to enhance nocturnal erections, stretch the tissue, encourage nourishment of the graft [159], and possibly reduce the risk of postoperative ED. Finally, the use of external penile traction therapy has been noted to reduce postoperative penile shortening for patients who have undergone either placation or grafting procedures. Traction is initiated 2–3 weeks postoperatively when the circumcising incision has adequately healed and is performed on a daily basis for a minimum of 2–8 hours for 3 months [181].

Table 5 outlines the results from published reports on grafting, on average 74–100% of patients were adequately straight, with a postoperative ED ranging from 5–53%.

Kalsi et al. studied 40 patients who underwent vein grafting and followed for at least 5 years. They reported a postoperative ED rate of 22.5% and a loss of length was noted in 35% [188]. At the 2004 Annual Meeting of the American Urological Association Society, Montorsi et al. reported on 50 patients with a 5-year follow-up after venous grafting where there was either persistent or recurrent curvature in 12%, length loss in 100%, postoperative ED in 22%, diminished orgasm in 41%, and overall patient satisfaction of only 60% [189]. Taylor and Levine recently reported a mean follow-up of just short of 5 years on 111 patients undergoing partial plaque excision with processed human pericardial grafting where the patients reported persistent or recurrent curvature of greater than 20° in 8% (none required surgical correction), a measured loss of stretched penile length was found in 47%, but was subjectively reported by 65% of patients. The postoperative ED rate was 24% with 31% noting diminished sensation, but 89% experienced normal orgasm. Overall, patient satisfaction was reported at 76% [157]. Postoperative traction therapy had not been introduced for these studies.

Recent studies have also examined the risk of postoperative ED following penile grafting procedures [175,177]. For the most part, no significant contribution was found because of the duration of disease, vascular risk factors (including diabetes, hypertension, elevated lipids, and smoking), a dorsal or lateral curvature, graft or tunica defect size, or whether there was preoperative narrowing or hinge effect. A higher risk of ED was found in those who underwent grafting for ventral curvature and there was a trend toward increased ED risk for men over the age of 60 [159]. In this published analysis, the primary component that helped predict an increased risk of postoperative ED was when the patient reported preoperative diminished rigidity.

**Table 5 Outcome of grafting procedures**

<table>
<thead>
<tr>
<th>Author</th>
<th>Date of publication</th>
<th>Pt #</th>
<th>Procedure type</th>
<th>% straight</th>
<th>% of ED</th>
<th>% of diminished sensation</th>
<th>Follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knoll [182]</td>
<td>2007</td>
<td>162</td>
<td>Plaque incision + SIS</td>
<td>91</td>
<td>21</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>Hatzimouratidis [183]</td>
<td>2002</td>
<td>17</td>
<td>Tunica albuginea free grafting</td>
<td>100</td>
<td>0</td>
<td>Not reported</td>
<td>39</td>
</tr>
<tr>
<td>Lue [184]</td>
<td>1998</td>
<td>112</td>
<td>Plaque incision + venous grafting</td>
<td>96</td>
<td>12</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>Gelbart [174]</td>
<td>1996</td>
<td>69</td>
<td>Plaque incision and temporalis fascia grafting</td>
<td>74</td>
<td>14</td>
<td>Not reported</td>
<td>Not reported</td>
</tr>
<tr>
<td>Egydio [180]</td>
<td>2002</td>
<td>33</td>
<td>Incision and bovine pericardium grafting</td>
<td>87.9</td>
<td>Not reported</td>
<td>Not reported</td>
<td>19</td>
</tr>
<tr>
<td>Levine [185]</td>
<td>2003</td>
<td>40</td>
<td>Tunical incision and human pericardium grafting</td>
<td>98</td>
<td>30</td>
<td>Not reported</td>
<td>22</td>
</tr>
<tr>
<td>Breyer [186]</td>
<td>2007</td>
<td>19</td>
<td>SIS graft</td>
<td>63</td>
<td>53</td>
<td>Not reported</td>
<td>15</td>
</tr>
<tr>
<td>Hsu [187]</td>
<td>2007</td>
<td>48</td>
<td>Plaque incision and venous grafting</td>
<td>90</td>
<td>5</td>
<td>Not reported</td>
<td>Not reported</td>
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</tbody>
</table>

SIS = small intestinal submucosa.
SURGERY—GRAFTING PROCEDURES
GRADE C
There is no evidence that surgical outcomes are consistently better with one graft type, and overall there is an increased risk of postoperative ED. Autologous grafts require more time and a second incision. Allograft and Xenograft procedures appear shorter in duration with no reported transmission of disease. Synthetic grafts increase the risk of infection and are not recommended.

Penile Prosthesis Implantation with Straightening Maneuvers
Finally, for those men who have poor quality erections and/or do not respond adequately to pharmacological therapy for their ED, penile prosthesis implantation is recommended. Table 6 reviews the recommended surgical algorithm for men with PD and ED [160,162].

Prosthesis alone may result in satisfactory straightening of the penis for those with mild deformity, but when residual curvature is more than 30°, manual modeling is recommended [190]. Manual modeling should be performed with care. Once the prosthesis is placed and the corporotomies are closed, the prosthesis is inflated with a surrogate (i.e., outside the body) reservoir of saline to demonstrate the deformity. The surgeon will then model the penis by bending it in the contralateral direction to the curvature maintaining the pressure on the bent penis for 30–60 seconds. The tubing between the pump and the cylinders should be occluded with rubber shod hemostats, so as to protect the pump from high pressure damage. In addition, when performing the modeling process, pressure on the glans penis should be avoided to prevent a urethral erosion by the cylinder tip. An alternative approach is to pre-place plication sutures in the 16-dot method before implanting the prosthesis and then tying them down to correct the curvature. Regardless of the approach, if there is residual curve less than 30°, no further treatment is recommended, as the prosthesis will act as an internal tissue expander and will likely result in correction of deformity in 6–9 months. On the other hand, if there is substantial residual curvature, then releasing incisions can be made on the concave side, often times through the same scrotal incision or may require degloving of the penis with elevation of Buck’s fascia. If these incisions create a tunica defect greater than 2 cm in any dimension, patching is recommended to decrease the risk of cicatrix contracture resulting in recurrent curvature or herniation of the cylinders. An off-the-shelf graft is now recommended to fix the tunica defect. Freshly harvested dermal grafts are not recommended as there is risk of transferring bacteria within the dermal tissue increasing the possibility of postoperative infection.

Table 6  Surgical algorithm with penile prosthesis

- Placement of inflatable prosthesis
- Manual modeling if residual curve >30°
- Plaque releasing incision if residual curve after modeling >30°
- Graft tunica if defect >2.0 cm to prevent implant herniation or cicatrix contracture

PD SURGERY—OVERVIEW GRADE D
Following published surgical algorithms is imperative, as well as obtaining a preoperative consent to set proper outcome expectations for the patient. A plication procedure is indicated for less severe deformity (<60°) and when there is borderline ED, while grafting is reserved for severe deformity (>60–70° ± hinge with normal erectile function) and requires an experienced surgical team. Lastly, prosthesis placement is indicated with additional maneuvers for those men with refractory ED and PD.
Peyronie’s Disease

Conclusion
This review is intended to be a guide to making decisions about surgical correction of PD. The intent is that it will be useful to the practicing surgeon so that they may provide appropriate advice to their patients regarding the proper surgical procedure. The most critical part of the surgeon’s role in the preoperative phase is to set appropriate expectations for the patient and to review the potential complications of surgery, including incomplete straightening, recurrent curvature, shaft shortening, diminished sensation, and ED. Although surgical correction of PD has historically had a negative reputation, the more recent refinements in technique make it a viable and successful treatment option for the properly selected patient.

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(b) Acquisition of Data
(c) Analysis and Interpretation of Data

Category 2
(a) Drafting the Article
(b) Revising It for Intellectual Content

Category 3
(a) Final Approval of the Completed Article

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