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REVIEW

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The role of imaging in patients with corporal fibrosis undergoing penile prosthesis placement: a narrative review

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Abstract

Penile prosthesis implantation (PPI) is a definitive solution for severe erectile dysfunction unresponsive to conventional therapies. However, in patients with corporal fibrosis (CF), the procedure presents significant challenges and higher complication risks. This narrative review explores the crucial role of imaging techniques, such as ultrasound and magnetic resonance imaging, in preoperative planning for PPI in patients with CF. Through a comprehensive literature search, we analyzed studies focusing on the efficacy of these imaging modalities in assessing fibrosis severity and guiding surgical strategies. Our findings highlight that advanced imaging provides essential insights into fibrosis extent, thereby optimizing surgical outcomes and reducing potential complications. The review underscores the importance of meticulous preoperative imaging in improving patient management and surgical precision in this complex clinical scenario.

Keywords

Penile fibrosis; Peyronie's disease; Priapism; Penile prosthesis; Imaging techniques

Técnicas de imagen y colocación de una prótesis de pene en pacientes con fibrosis corporal: una revisión narrativa

Resumen

La implantación de prótesis de pene (IPP) es una solución definitiva para la disfunción eréctil grave que no responde a las terapias convencionales. Sin embargo, en pacientes con fibrosis corporal (FC), el procedimiento presenta retos significativos y mayores riesgos de complicaciones. Esta revisión narrativa explora el papel crucial de las técnicas de imagen, como la ecografía y la resonancia magnética, en la planificación preoperatoria de la IPP en pacientes con FC. Mediante una exhaustiva búsqueda bibliográfica, se analizaron estudios centrados en la eficacia de estas modalidades de imagen para evaluar la gravedad de la fibrosis y orientar las estrategias quirúrgicas. Nuestros hallazgos destacan que la imagenología avanzada proporciona información esencial sobre la extensión de la fibrosis, optimizando así los resultados quirúrgicos y reduciendo las posibles complicaciones. La revisión subraya la importancia de un diagnóstico por imagen preoperatorio meticuloso para mejorar el tratamiento de los pacientes y la precisión quirúrgica en este complejo escenario clínico.

Palabras Clave

Fibrosis peneana; Enfermedad de peyronie; Priapismo; Prótesis peneana; Técnicas de imagen

1. Introduction and background

Penile prostheses implantation (PPI) stands as a viable option for men undergoing severe erectile dysfunction (ED) unresponsive to standard medical interventions, offering a more enduring therapeutic resolution [1]. Over the past decades, significant improvements in devices and procedural techniques have established PPI as a reliable treatment modality, characterized by its high safety profile, mechanical resilience, and patient satisfaction [2]. Despite these advancements, PPI may be a complex surgical procedure that entails the risk of substantial complications, which may exert long-lasting effects [3, 4]. Current research strongly indicates that certain patient groups, such as those with corporal fibrosis (CF) and those undergoing revisionary or salvage PPI, are more susceptible to complications, particularly infection and erosion of the device [5].

CF emerges as a pathological entity, characterized by the pathological transformation of the penile normal elastic fibrous components into dense, collagen-rich, fibrotic tissue [6]. This complex condition arises from a number of etiological factors, such as post-priapism sequelae, iatrogenic outcomes, explantation of a previously placed penile prosthesis, and as a pathological manifestation of Peyronie's disease (PD) [5, 6]. The underlying pathophysiological mechanisms of CF involve inflammatory processes culminating in excessive collagen deposition and fibrotic tissue formation [6].

The impact of CF transcends the physical symptoms, having a great impact on the psychosocial dynamics and sexual wellness of those affected [6]. This condition, often culminating in ED, may lead to further complications such as penile deformities and notable shortening of the penis in its more severe forms, thus intensifying the complexities inherent in its clinical management [7]. In addressing the most severe instances of CF, the strategic placement of penile prostheses emerges as a pivotal element of the treatment. In this approach, it is necessary a high degree of surgical precision and careful preoperative consideration, given the intricate nature of the procedure and the higher risk of complications such as urethral injury resulting in urethral stenosis, glans necrosis or glans hyposensitivity [8]. In this context, an accurate preoperative evaluation of fibrosis severity through advanced imaging techniques becomes essential. Such meticulous assessment not only aids in anticipating the extent of fibrosis but also facilitates more detailed and tailored surgical planning, thereby optimizing patient outcomes and mitigating potential risks [9].

This comprehensive narrative review aims to elucidate the pivotal role of imaging techniques in the management of patients with severe CF undergoing PPI.

The importance of this review lies in the fact that, while imaging plays a critical role in the management of patients with severe CF undergoing PPI, no comprehensive reviews have specifically addressed this issue. This gap in the literature highlights the need for an in-depth exploration of how imaging techniques, particularly ultrasound and MRI, can enhance the precision and success of PPI in this challenging patient population.

2. Materials and methods

A comprehensive literature search was performed using MEDLINE, EMBASE and Cochrane Central Controlled Register of Trials (CENTRAL). We employed MeSH terms and keywords relevant to penile fibrosis and imaging techniques, such as "penile fibrosis", "corporal fibrosis", "Peyronie's disease", "priapism", "post-priapism", "penile prosthesis", "imaging", "ultrasound", "MRI", "CT scan" and "salvage surgery".

The search was inclusive of all studies, with no date restrictions, and focused on English-language articles, excluding animal studies. The reviewers team favoured the inclusion of articles from 2013 to 2024 to give up-to-date information, although relevant publications older than 10 years were also included. A list was made of the most relevant literature by abstract and title, which consisted of a total of 110 articles.

The reference lists of articles identified by this search strategy were also reviewed, and the working group selected relevant references. Each publication has been reviewed by at least two reviewers and when there was no consensus a third reviewer decided on its inclusion. A total of 36 relevant articles were selected for inclusion in the narrative review, although during the writing of the manuscript, others were included according to context.

This review was intended to provide expert commentary on the topic and not intended to be a systematic review.

3. Results

3.1 PRIAPISM

Priapism is a prolonged and painful erection that occurs in the absence of sexual stimulation. This condition (more specifically low flow priapism or ischemic priapism, IP) can result in permanent erectile dysfunction (ED) if left untreated [10]. The main goal of IP management is to resolve the painful erection before irreversible fibrosis, preserve erectile function and prevent penile shortening. In patients with a prolonged episode, irreversible smooth muscle necrosis is likely to have already occurred and medically refractory ED is likely to occur despite the resolution of IP [11].

The duration of the episode is the key point for choosing the treatment modality and in episodes >72 hours, an immediate PPI could be offered to preserve erectile function and prevent penile shortening from CF [12]. The restoration of oxygenation to the corpora cavernosa through surgical intervention does not appear to mitigate the subsequent necessity for penile prosthesis (PP) implantation in the presence of extensive ischemic damage to the smooth muscle tissue [11, 12].

To resolve acute priapism, prevent unnecessary shunt procedures, and in cases where the corpora cavernosa are entirely occluded following unsuccessful surgical shunting attempts, it is advisable to determine the extent of corporal smooth muscle necrosis through imaging techniques or intraoperative biopsies of corporal muscle [11] as an early implantation of a PP may obtain the most favourable functional outcome [13–15].

In addition, the presence of CF will mean a higher risk of perioperative complications, so its exhaustive study will facilitate surgical planning. A current study observed a higher frequency of complications during PPI surgery in men who

previously experienced priapism [16]. In their study, the extensive corporeal fibrosis made the dilation of the corpora challenging, leading to urethral injuries in two cases.

3.1.1 Sonography

Ultrasonography (US) can play a crucial role in determining the permeability of cavernosal arteries and identifying pathologic changes in the echotexture of the corpora cavernosa. Initially, in cases of IP, the corpora cavernosa may appear normal. The presence of static blood can be detected as a sedimentation of blood, which forms a fluid-fluid level. As the condition advances, tissue edema is likely to cause an increase in the echogenicity of the corpora cavernosa [9, 17].

In long-standing cases of IP, the US can reveal extensive alterations in the echotexture of the corpora cavernosa, indicative of fibrotic changes [18]. Given that the penis is already erect in these situations, US examinations should be conducted without the injection of vasoactive drugs into the cavernosa.

This detailed imaging approach, as outlined by Bertolotto *et al.* [19], provides vital insights into the progression of IP, aiding in the assessment of tissue viability and guiding appropriate therapeutic interventions, such as IPP.

Although some reports incorporate US innovatively prior to PPI surgery in cases of corporeal fibrosis due to IP, and this technique has significantly improved the accuracy and safety of the procedure, magnetic resonance imaging (MRI) offers greater sensitivity and more accurate images, so its use is not standardised.

Although some reports incorporate US innovatively prior to PPI surgery in cases of corporeal fibrosis due to IP, and this technique has significantly improved the accuracy and safety of the procedure, magnetic resonance imaging (MRI) offers greater sensitivity and more accurate images in certain aspects. However, the use of MRI is not always standardised due to its higher cost and limited availability [20, 21].

3.1.2 Magnetic resonance imaging

MRI can provide valuable information to assist in the decision-making process for PPI [12]. MRI is useful in evaluating IP as it can identify the presence of fibrosis and may be used to assess the viability of the corpora cavernosa [13]. The extent of infarction identified via MRI exhibits a strong correlation with other (though with less anatomically accuracy) diagnostic modalities, such as US and blood gas measurement, as well as with histological assessments [22].

Different studies suggest that the use of MRI in patients with priapism prior to PPI is important for the proper evaluation of the anatomy and the presence of penile disorders [22, 23]. MRI is particularly useful for assessing the extent of fibrosis and evaluating the presence of cavernosal arterial flow. It can also help to differentiate between low-flow and high-flow priapism, which is crucial for the selection of appropriate treatment. In ischemic priapism, typical MRI findings include non-enhancement of the corpus cavernosa with strong enhancement of the corpus spongiosum post-contrast [20].

David Ralph *et al.* [22] discussed the utility of the non-invasive evaluation of tissue damage using high-resolution MRI in the management of patients with IP to aid in the formulation of individualized treatment plans. The authors observe that in patients who underwent corpus cavernosum biopsy and MRI, the sensitivity of MRI in predicting the non-viability of smooth muscle was 100% and conclude that MRI can be a valuable tool in the management of patients with IP. So they recommend that it should be considered as an important part of the diagnostic and treatment process of IP.

Citing the last mentioned paper, which is the only one published with clinical experience and which compares this imaging modality with biopsy results, European Association of Urology (EAU) guidelines recommend MRI evaluation in cases of prolonged ischemic priapism given its high sensitivity in predicting non-viable smooth muscle [1]. However, given the time-sensitivity of diagnosis and treatment of IP, it is likely that MRI will not have a role in the initial phase of diagnosis and treatment of IP [24].

MRI can then be useful in the subacute phase (after initial management) to assess for tissue viability and potential long-term complications. This type of imaging is particularly relevant for cases of IP lasting more than 36 hours, where the risk of tissue damage increases significantly [1]. For IP lasting over 72 hours, MRI can also provide valuable information on the extent of IP and help in planning further therapeutic strategies. Therefore, MRI's role is generally limited to a later stage when initial urgent interventions have already been performed [24, 25].

In summary, while MRI is not typically used during the initial emergency management of IP, it becomes valuable after 36–72 hours to assess the extent of tissue damage and plan further treatment. Although the scientific evidence is very limited, there appears to be a widespread recommendation for the use of MRI in IP patients prior to PPI to potentially lead to a more effective clinical management pathway.

3.2 Peyronie's disease

Peyronie's Disease (PD) is a connective tissue disorder localized in the fascial tunica albuginea (TA), covering the penile cavernous bodies. This condition causes the formation of palpable scars or solid plaques, mostly on the dorsal side of the penis, leading to penile deformities and changes in penile length and circumference while penile erection [26]. The acute phase of PD, typically lasting 6–18 months, begins with the onset and progression of penile deformity and is often accompanied by pain in either a flaccid or erected state, or both. The chronic phase is defined by the stability of the penile deformity for at least 6 months [27].

PD presents most commonly in men in their sixth decade of life, with a prevalence reported up to 8–13% [28]. Currently, it is widely hypothesized that microtrauma might lead to an inflammatory response in the TA, leading to an inflammatory response. This involves activation of immune cells and increased production of certain molecules, like Transforming growth factor beta 1 (TGF-β1) and plasminogen activator inhibitor 1, which cause fibroblasts to turn into myofibroblasts. This results in excessive extracellular matrix formation, causing fibrosis in the tunica albuginea and possibly extending to the corpora cavernosa [29].

In about 32% of the patients, PD is frequently accompanied by vasculogenic ED [30]. The exact pathogenic mechanism or

cause of ED in PD remains unclear, but fibrosis of cavernosal blood vessels seems to play a certain role in the progression of PD as well as ED, providing the potential hypotheses of having a unifying origin [31, 32].

Although the incidence and prevalence of CF in PD patients are not well defined, results from the PROPER study [33] indicated that 51.2% of men with PD who underwent PPI exhibited corporal fibrosis intraoperatively. Consequently, in addition to assessing the size and presence of tunical plaques, it's crucial to identify the potential of CF preoperatively or to evaluate the severity of the CF for surgical planning [34].

Several imaging modalities have been studied in the evaluation of PD: computer tomography, radiography, MRI, US and elastography [35, 36]. However, Greys scale US and Penile duplex doppler ultrasonography (PDDU) are the gold standard to detect vascular and non-vascular abnormalities. Further, penile MRI provides an accurate imaging method to assess smooth muscle viability [35, 37, 38].

3.2.1 Sonography

US is recognized as a safe, cost-effective, and efficient method for objectively evaluating plaque size, location, and calcification in PD, offering an alternative for diagnosis. It plays a crucial role in determining the presence of ED concurrently. Particularly after intracavernosal injections, the US emerges as the most accurate tool for assessing the type and extent of PD deformities and for evaluating penile anatomy and dynamic blood flow. This approach is generally preferred over photographic ethods or erections induced by vacuum erectile devices [30, 39].

Sonography excels in enhancing the detection of lesions, especially those in the TA and septum, which may be less contrasted with surrounding tissues. Its capability to efficiently identify calcified lesions remains effective irrespective of the penile state [40].

PDDU is a valuable tool to characterize penile vasculature and flow after intracavernosal injection of vasoactive agents. Notably, doppler spectra from both cavernosal arteries should be captured, measuring both peak systolic and end-diastolic velocities for a duration of at least 30 minutes following the injection [39, 41]. This examination allows to identify anatomical vascular variations, arterial vascular anastomosis, arterial inflow, and venous outflow. Further, critical information such as if the plaques contain the neurovascular bundles or cavernosal artery can be detected [42]. Such detailed insights are essential for effective surgical planning.

The role of hyperperfusion around a plaque as an indicator of acute inflammation remains debated among experts [35].

In the case of CF, sonography typically reveals a hyperechoic, heterogeneous region within the corpora, characterized by echogenic strands surrounding the cavernosal arteries and replacing the corpora cavernosal's sinusoids. These changes are usually not evident post-vasoactive drug injection. Additionally, Doppler ultrasonography often reveals signs of venogenic dysfunction [39, 41, 43, 44]. Despite the utility of the Kelami classification for plaque categorization [45], there remains a notable absence of a universally accepted definition and measurement standard for CF.

3.2.2 Magnetic resonance imaging

MRI is a valuable tool for visualizing the erectile bodies, fascial layers, septum, and vascular structure of the penis, providing excellent soft-tissue contrast across multiple planes [46]. Despite its limitations in depicting calcified plaques, MRI offers crucial insights into plaque formation, especially at the penile base, and is particularly useful in cases with a high clinical suspicion for PD but negative findings in physical examinations and US [47, 48].

MRI's ability to detect non-calcified plaques is enhanced through the use of perifocal gadolinium enhancement, which highlights inflammatory reactions around the plaque. However, the correlation of plaque enhancement with histological changes remains under-explored, with limited studies involving small patient groups [49] and showing no clear association between enhancement and penile pain, traditionally considered an indicator of active PD [47].

The technique excels in assessing the extent, position and involvement of the corpora cavernosa or septum in patients with PD, offering detailed insights crucial for surgical planning [46, 48, 50]. Despite its advantages, MRI's limited availability prevents it from being routinely used in PD evaluations. Nevertheless, where available, MRI surpasses the US in accurately depicting penile deformities, the thickness of the tunica albuginea, the positioning of plaques, induration of the septum and the diameter of the cavernosal bodies, making it invaluable, especially in complex cases where precise surgical interventions are required [50].

In summary, ultrasound and PDDU are essential tools for assessing vascular and non-vascular abnormalities and characterizing penile vasculature and MRI provides more precise anatomical details, especially in complex cases requiring surgical planning. The combined use of these imaging techniques enhances diagnostic accuracy and treatment planning, addressing both structural and functional aspects of the disease.

3.3 Corporal fibrosis after explanted device

Despite advancements in penile prostheses devices design, surgical techniques, and careful patient selection, the occurrence of prosthetic infections remains a challenge. Early salvage procedures for penile prostheses, notably popularized by Brant *et al*. [51], have largely supplanted delayed salvage surgeries [52]. The primary advantage of immediate salvage is the preservation of the implant and the prevention of severe CF and penile shortening.

Traditionally, management of a prosthetic infection or erosion involves removing all prosthetic components and rigorously irrigating the infected areas. This approach often leads to corporal fibrosis and a reduction in penile size. Traction therapy using an external penile mechanical extender or a vacuum erection device has shown promise in enhancing penile size and patient satisfaction [53]. However, this mechanical therapy demands strict adherence from the patient, with only modest improvements in penile length and girth anticipated. Moreover, patients with a history of IPP explanation and severe CF are at a higher risk of intraoperative and postoperative complications. These include difficulties in dilating the corpora, risk of urethral injury, and postoperative issues such as

prosthesis infection, erosion, or malfunction. Studies reported operative infection rates for IPP placement were 2.1% and 6.5% for primary placement *vs.* secondary or revisional IPP surgery, respectively [9].

To circumvent significant CF that complicates future implantations, immediate salvage IPP placement is recommended [51]. Recently, there has been growing interest in utilizing malleable devices or biomaterials during salvage procedures [54]. These serve as temporary space-fillers to avert fibrosis and facilitate delayed conversion to an inflatable PP (IPP), simplifying the placement of new cylinders and preserving penile length during erections. Furthermore, once implanted, some patients find malleable rods adequate for sexual activity and do not need their change for an IPP [54].

Mulcahy *et al.* [51] significantly advanced the concept of salvage surgery, by introducing a cocktail of betadine, hydrogen peroxide, and kanamycin/bacitracin for antibiotic solution. Mulcahy's innovative approach has broadened the scope and challenged the traditional perception of immediate salvage surgery in the context of prosthetic infection. Contraindications to the salvage IPP placement include tissue necrosis, diabetic patients with pus in the corporal bodies, rapidly progressing infections, and erosion of the device cylinders [55].

Even with strategies to mitigate scarring, IPP implantation and explanation may cause fibrosis of the penile corpora [56, 57] and, in the context of severe CF, when an immediate salvage strategy is not possible, anatomical assessment and preoperative imaging are critical.

3.3.1 Sonography

Although scientific evidence in this setting is very scarce, the US seems to be considered a useful instrument in evaluating penile fibrosis subsequent to the placement or removal of PP [9]. Accurately detecting significant cavernosal fibrotic alterations, the US seems essential for selecting an appropriate surgical approach. Extensive CF can hinder the success of certain re-implantation techniques for PPI [58].

When a patient's medical history and physical examination suggest possible post-surgical fibrosis, findings from ultrasound imaging can be instrumental in confirming the diagnosis. Post-surgical changes in the penis, as detected *via* ultrasound, manifest as specific zones of localized fibrosis. This fibrosis appears on ultrasound as an area of inconsistent echogenic tissue. During a longitudinal ultrasound examination of the erect penis, certain transverse views will reveal areas with heightened echogenicity and thickness. These localized fibrotic zones indicate regions where previous surgical incisions or infections have induced localized corporal fibrosis [59]. It's important to distinguish circumscribed fibrosis from diffuse fibrosis, where the entire length and circumference of the corpora exhibit increased echogenicity and thickness.

3.3.2 Magnetic resonance imaging

MRI is recognized as the primary imaging method for diagnosing issues with IPP. It offers outstanding resolution for soft tissue contrast and direct imaging in multiple planes. When an infected PP is present, soft tissue infection and inflammation manifest as an increase in soft tissue thickness, showing up as areas of increased signal intensity and enhanced contrast on T2 imaging around the device components. Suspected abscesses and infected fluid collections are indicated by localized fluid accumulations surrounded by a rim of thickened and enhanced soft tissue. However, the imaging traits of the infection do not provide a means to distinguish between different causative organisms.

Kim *et al.* [60] conducted a study to evaluate the role of MRI in surgical decision-making in patients with difficult presentations related to IPP. The study focused on patients presenting with complications such as discomfort, penile deformities and problems with prosthesis inflation. They conclude that MRI proves to be a valuable tool for confirming suspected diagnoses and guiding surgical treatment decisions.

Although MRI is the most sensitive test for fibrosis assessment, and its usefulness as a pre-surgical evaluation is known, due to the fact that it is globally accepted an immediate prosthesis replacement when there are complications (salvage surgery), we have not found scientific literature that evaluates in a targeted way the role of imaging techniques to assess fibrosis prior to placement of a new PP in patients with previous prosthesis explanation.

In summary, corporal fibrosis after the explanation of a penile prosthetic device presents a significant challenge for future reimplantation. Ultrasound is valuable for detecting significant fibrotic changes and guiding the surgical approach and MRI offers detailed assessment of complications and enhances the visualization of structural anomalies and infections, being crucial for surgical planning in complex re-implantation scenarios.

Table 1 presents a summary of key information based on the authors' literature review, categorised by pathology and imaging test.

4. Strengths and limitations

A limitation of our study stems from its narrative review design, which does not involve the rigorous systematic methodology inherent in systematic reviews. This format may limit the comprehensiveness and conclusiveness of our conclusions. However, we assert that our review, conducted by a team of professionals of recognized prestige in the field, offers valuable insights and a broad overview of the subject, serving as a platform for future systematic examinations.

5. Conclusions

This comprehensive review delineates the indispensable role of advanced imaging modalities in the evaluation and management of patients with severe corporal fibrosis undergoing penile prosthesis implantation. It accentuates the intricate challenges presented by conditions such as Peyronie's Disease and the sequelae of post ischemic priapism, underlining the critical need for an exhaustive preoperative assessment employing ultrasound and Magnetic Resonance Imaging. Essential findings are included in Table 1.

TABLE 1. Summary statements on the role of imaging in patients with corporal fibrosis undergoing salvage penile prosthesis placement.

Pathology	Imaging technique	Key utilization and findings
Ischemic priapism		
	US	- Essential for early detection of changes in the cavernosal arteries and corpora cavernosa. - Identifies initial normal appearance, increased echogenicity indicating tissue edema, and eventual fibrotic alterations in chronic cases.
	MRI	- Critical for determining the extent of corporal smooth muscle necrosis (100% sensitivity). - Useful for predicting irreversible erectile dysfunction. - Preferred for evaluating chronic cases and distinguishing priapism types. - Aids in treatment decision-making; EAU guidelines advocate MRI evaluation in prolonged ischemic priapism.
Peyronie's disease		
	US	- Good for assessing plaque size, location, and calcification. - Accurately evaluates erectile dysfunction and deformities post-intracavernosal injections - Doppler US characterizes penile vasculature, identifying vascular anomalies and assessing blood flow dynamics. - Use of hyperperfusion around a plaque as a sign of acute inflammation remains contentious.
	MRI	- Visualizes erectile bodies, fascial layers, and vasculature with superior soft-tissue contrast. - Detects non-calcified plaques and provides comprehensive anatomical details for surgical planning. - Useful in complex surgical cases despite limitations with calcified plaques. - Lack of consensus on routine use.
Corporal fibrosis after explanted device		
	US	- Evaluates penile fibrosis following IPP interventions. - Identifies fibrotic changes within corpora cavernosa to guide future surgical approaches.
	MRI	- Assesses complications in IPP cases with detailed soft tissue contrast. - Enhances visualization of structural anomalies and infections. - Crucial for surgical planning in complex re-implantation scenarios. - Lack of targeted scientific literature on imaging techniques.

EAU: European Association of Urology; IPP: Inflatable Penile Prosthesis; MRI: Magnetic Resonance Imaging; PD: Peyronie's Disease; US: Ultrasound.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

EGR, JRO and DO—designed the research study. EGR and LK—performed the research. EGR, LK, JRO and DO—wrote the manuscript. BGG, MAI and IM—provided help and advice on writing the final version of the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] European Association of Urology. Management of erectile dysfunction. 2024. Available at: https://uroweb.org/guidelines/sexual-and-reproductive-health/chapter/management-of-erectile-dysfunction (Accessed: 14 January 2024).

[2] Manfredi C, Fortier É, Faix A, Martínez-Salamanca JI. Penile implant surgery satisfaction assessment. The Journal of Sexual Medicine. 2021; 18: 868–874.

[3] Byrne ER, Ungerer GN, Ziegelmann MJ, Kohler TS. Complications and troubleshooting in primary penile prosthetic surgery—a review. International Journal of Impotence Research. 2023; 35: 679–685.

[4] Fernandez Crespo RE, Stroie F, Taylor L, Pignanelli M, Parker J, Carrion

R. Penile fibrosis—still scarring urologists today: a narrative review. Translational Andrology and Urology. 2024; 13: 127–138.

[5] Martínez-Salamanca JI, Mueller A, Moncada I, Carballido J, Mulhall JP. Penile prosthesis surgery in patients with corporal fibrosis: a state of the art review. The Journal of Sexual Medicine. 2011; 8: 1880–1889.

[6] Gonzalez-Cadavid NF. Mechanisms of penile fibrosis. The Journal of Sexual Medicine. 2009; 6: 353–362.

[7] Levine LA. The clinical and psychosocial impact of Peyronie's disease. The American Journal of Managed Care. 2013; 19: S55–S61.

[8] Tsambarlis PN, Chaus F, Levine LA. Successful placement of penile prostheses in men with severe corporal fibrosis following vacuum therapy protocol. The Journal of Sexual Medicine. 2017; 14: 44–46.

[9] Kim J, Drury R, Morenas R, Raheem O. Pathophysiology and grayscale ultrasonography of penile corporal fibrosis. Sexual Medicine Reviews. 2022; 10: 99–107.

[10] Biebel MG, Gross MS, Munarriz R. Review of ischemic and non-ischemic priapism. Current Urology Reports. 2022; 23: 143–153.

[11] Yücel ÖB, Pazır Y, Kadıoğlu A. Penile prosthesis implantation in priapism. Sexual Medicine Reviews. 2018; 6: 310–318.

[12] Reddy AG, Alzweri LM, Gabrielson AT, Leinwand G, Hellstrom WJG. Role of penile prosthesis in priapism: a review. The World Journal of Men's Health. 2018; 36: 4–14.

[13] Kirkham A. MRI of the penis. The British Journal of Radiology. 2012; 85: S86–S93.

[14] Barham DW, Chang C, Hammad M, Pyrgidis N, Swerdloff D, Gross K, *et al*. Delayed placement of an inflatable penile prosthesis is associated with a high complication rate in men with a history of ischemic priapism. The Journal of Sexual Medicine. 2023; 20: 1052–1056.

[15] Salman B, Elsherif E, Elgharabawy M, Badawy A. Early versus delayed penile prosthesis insertion for refractory ischemic priapism. Arab Journal of Urology. 2023; 21: 76–81.

[16] Durazi MH, Jalal AA. Penile prosthesis implantation for treatment of postpriapism erectile dysfunction. Urology Journal. 2008; 5: 115–119.

[17] von Stempel C, Walkden M, Kirkham A. Review of the role of imaging in the diagnosis of priapism. To be published in International Journal of Impotence Research. 2024. [Preprint].

[18] von Stempel C, Shahzad R, Walkden M, Castiglione F, Muneer A, Ralph D, *et al*. Therapeutic outcomes and analysis of Doppler findings in 25 patients with non-ischemic priapism. International Journal of Impotence Research. 2024; 36: 55–61.

[19] Bertolotto M, Pavlica P, Serafini G, Quaia E, Zappetti R. Painful penile induration: imaging findings and management. Radiographics. 2009; 29: 477–493.

[20] Kirkham APS, Illing RO, Minhas S, Minhas S, Allen C. MR imaging of nonmalignant penile lesions. Radiographics. 2008; 28: 837–853.

[21] Wilson SK, Delk JR, Mulcahy JJ, Cleves M, Salem EA. Upsizing of inflatable penile implant cylinders in patients with corporal fibrosis. The Journal of Sexual Medicine. 2006; 3: 736–742.

[22] Ralph DJ, Borley NC, Allen C, Kirkham A, Freeman A, Minhas S, *et al*. The use of high-resolution magnetic resonance imaging in the management of patients presenting with priapism. BJU International. 2010; 106: 1714–1718.

[23] BAUS Section of Andrology Genitourethral Surgery; Muneer A, Brown G, Dorkin T, Lucky M, Pearcy R, Shabbir M, *et al*. BAUS consensus document for the management of male genital emergencies: priapism. BJU International. 2018; 121: 835–839.

[24] American Urological Association. Diagnosis and management of priapism: AUA/SMSNA guideline (2022). 2022. Available at: https://www.auanet.org/guidelines-and-quality/guidelines/diagnosis-and-management-of-priapism-aua/smsna-guideline-(2022) (Accessed: 16 February 2023).

[25] Bivalacqua TJ, Allen BK, Brock GB, Broderick GA, Chou R, Kohler TS, *et al*. The diagnosis and management of recurrent ischemic priapism, priapism in sickle cell patients, and non-ischemic priapism: an AUA/SMSNA guideline. The Journal of Urology. 2022; 208: 43–52.

[26] Paulis G, Romano G, Paulis A. Prevalence, psychological impact, and risk factors of erectile dysfunction in patients with Peyronie's disease: a retrospective analysis of 309 cases. Research and Reports in Urology. 2016; 8: 95–103.

[27] Mulhall JP, Schiff J, Guhring P. An analysis of the natural history of Peyronie's disease. The Journal of Urology. 2006; 175: 2115–2118.

[28] Al-Thakafi S, Al-Hathal N. Peyronie's disease: a literature review on epidemiology, genetics, pathophysiology, diagnosis and work-up. Translational Andrology and Urology. 2016; 5: 280–289.

[29] Milenkovic U, Ilg MM, Cellek S, Albersen M. Pathophysiology and future therapeutic perspectives for resolving fibrosis in Peyronie's disease. Sexual Medicine Reviews. 2019; 7: 679–689.

[30] M Hellstrom WJG, Trost L. Persistent penile abnormalities in men with Peyronie's disease. Nature Clinical Practice Urology. 2006; 3: 634–635.

[31] Azadzoi KM, Schulman RN, Aviram M, Siroky MB. Oxidative stress in arteriogenic erectile dysfunction: prophylactic role of antioxidants. The Journal of Urology. 2005; 174: 386–393.

[32] Gonzalez-Cadavid NF, Rajfer J. Therapy of erectile dysfunction. Endocrine. 2004; 23: 167–176.

[33] Khera M, Bella A, Karpman E, Brant W, Christine B, Kansas B, *et al*. Penile prosthesis implantation in patients with Peyronie's disease: results of the PROPPER study demonstrates a decrease in patient-reported depression. The Journal of Sexual Medicine. 2018; 15: 786–788.

[34] Zhao S, Wu X, Zhang Y, Zhang C. Role of shear wave elastography in the diagnosis of Peyronie disease. Journal of Ultrasound in Medicine. 2024; 43: 397–403.

[35] Kalokairinou K, Konstantinidis C, Domazou M, Kalogeropoulos T, Kosmidis P, Gekas A. US imaging in Peyronie's disease. Journal of Clinical Imaging Science. 2012; 2: 63.

[36] Pawłowska E, Bianek-Bodzak A. Imaging modalities and clinical assessment in men affected with Peyronie's disease. Polish Journal of Radiology. 2011; 76: 33–37.

[37] Parmar M, Masterson JM, Masterson TA 3rd. The role of imaging in the diagnosis and management of Peyronie's disease. Current Opinion in Urology. 2020; 30: 283–289.

[38] Aversa A, Crafa A, Greco EA, Chiefari E, Brunetti A, La Vignera S. The penile duplex ultrasound: how and when to perform it? Andrology. 2021; 9: 1457–1466.

[39] Varela CG, Yeguas LAM, Rodríguez IC, Vila MDD. Penile doppler ultrasound for erectile dysfunction: technique and interpretation. American Journal of Roentgenology. 2020; 214: 1112–1121.

[40] Liu Y, Zheng D, Liu X, Shi X, Shu S, Li J. Ultrasound on erect penis improves plaque identification in patients with Peyronie's disease. Frontiers in Pharmacology. 2019; 10: 312.

[41] Wilkins CJ, Sriprasad S, Sidhu PS. Colour doppler ultrasound of the penis. Clinical Radiology. 2003; 58: 514–523.

[42] Schaeffer EM, Jarow JP, Vrablic J, Jarow JP. Duplex ultrasonography detects clinically significant anomalies of penile arterial vasculature affecting surgical approach to penile straightening. Urology. 2006; 67: 166–169.

[43] Lindquist CM, Nikolaidis P, Mittal PK, Miller FH. MRI of the penis. Abdominal Radiology. 2020; 45: 2001–2017.

[44] von Stempel C, Walkden M. Duplex ultrasonography and its role in the assessment of male sexual dysfunction. In Minhas S, Mulhall J (eds.) Male sexual dysfunction: a clinical Guide (pp. 91–101). 1st edn. John Wiley & Sons Ltd.: Newark. 2017.

[45] Levine L, Rybak J, Corder C, Farrel MR. Peyronie's disease plaque calcification—prevalence, time to identification, and development of a new grading classification. The Journal of Sexual Medicine. 2013; 10: 3121–3128.

[46] Lindquist CM, Nikolaidis P, Mittal PK, Miller FH. MRI of the penis. Abdominal Radiology. 2020; 45: 2001–2017.

[47] Hauck EW, Hackstein N, Vosshenrich R, Diemer T, Schmelz HU, Bschleipfer T, *et al*. Diagnostic value of magnetic resonance imaging in Peyronie's disease—a comparison both with palpation and ultrasound in the evaluation of plaque formation. European Urology. 2003; 43: 293–300.

[48] Abualruz AR, O'Malley R, Ponnatapura J, Holbert BL, Whitworth P, Tappouni R, *et al*. MRI of common penile pathologies and penile prostheses. Abdominal Radiology. 2020; 45: 2825–2839.

[49] Helweg G, Judmaier W, Buchberger W, Wicke K, Oberhauser H, Knapp R, *et al*. Peyronie's disease: MR findings in 28 patients. American Journal of Roentgenology. 1992; 158: 1261–1264.

[50] Pretorius ES, Siegelman ES, Ramchandani P, Banner MP. MR imaging of the penis. RadioGraphics. 2001; 21: S283–S298.

[51] Brant MD, Ludlow JK, Mulcahy JJ. The prosthesis salvage operation: immediate replacement of the infected penile prosthesis. The Journal of Urology. 1996; 155: 155–157.

[52] Knoll LD. Penile prosthetic infection: management by delayed and immediate salvage techniques. Urology. 1998; 52: 287–290.

[53] Antonini G, De Berardinis E, Busetto GM, Del Giudice F, Chung BI, Conti SL, *et al*. Postoperative vacuum therapy following AMSTM LGX 700® inflatable penile prosthesis placement: penile dimension outcomes and overall satisfaction. International Journal of Impotence Research. 2020; 32: 133–139.

[54] Lao M, Graydon RJ, Bieniek JM. Salvage penile prosthetic surgery utilizing temporary malleable implants. Translational Andrology and Urology. 2017; 6: S806–S812.

[55] Adams ES, Tua-Caraccia RD, Lentz AC. Narrative review of immediate salvage for penile prosthesis infection. Translational Andrology and Urology. 2024; 13: 584–595.

[56] Lledó García E, González García FJ, Martínez Holguin E, Hernandez Cavieres J, Polanco Pujol L, Jara Rascón J, *et al*. Surgical implant options in patients with penile fibrosis due to infection or previous explants. Actas Urologicas Españolas. 2020; 44: 268–275.

[57] Schifano N, Capogrosso P, Cakir OO, Dehò F, Garaffa G. Surgical tips in difficult penile prosthetic surgery: a narrative review. International Journal of Impotence Research. 2023; 35: 690–698.

[58] Montague DK, Angermeier KW. Corporeal excavation: new technique for penile prosthesis implantation in men with severe corporeal fibrosis. Urology. 2006; 67: 1072–1075.

[59] Bertolotto M, Martingano P, Ukmar M. Penile scar and fibrosis. In Bertolotto M (ed.) Color doppler US penis (pp. 153–162). 1st edn. Springer: Berlin, Heidelberg. 2008.

[60] McPhail EF, Nehra A, Bruner BC, Kawashima A, King BF, Kim B. MRI and its role in the evaluation and surgical decision making in patients with challenging IPP presentations: descriptions of MRI findings and algorithm for patient management. BJU International. 2012; 109: 1848–1852.

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