Review Article

Penile prosthesis in priapism: a systematic review of outcomes and complications

David A. Velasquez[1]^, Paulo Vitor Barreto Guimaraes[2]^, Hernan Lescay[2]^, Omer Raheem[2]^

[1]Pritzker School of Medicine, The University of Chicago, Chicago, IL, USA; [2]Section of Urology, Department of Surgery, The University of Chicago Medicine, Chicago, IL, USA

Contributions: (I) Conception and design: O Raheem, PVB Guimaraes; (II) Administrative support: All authors; (III) Provision of study materials or patients: DA Velasquez, PVB Guimaraes, H Lescay; (IV) Collection and assembly of data: DA Velasquez, PVB Guimaraes, H Lescay; (V) Data analysis and interpretation: DA Velasquez, PVB Guimaraes, H Lescay; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Omer Raheem, MD. Section of Urology, Department of Surgery, The University of Chicago Medicine, 5841 S. Maryland Avenue, Chicago, IL 60637, USA. Email: oraheem@bsd.uchicago.edu.

Background: Priapism is a rare condition characterized by persistent erection of the penis that lasts more than 4 hours in the absence of sexual stimulation and is associated with significant morbidity and complications, including erectile dysfunction and penile fibrosis. Surgical management of priapism can be extremely challenging. We herein provide a comprehensive review that aims to evaluate the role of penile prosthesis (PP) implantation in the management of priapism.

Methods: A systematic literature search was performed using the following databases: PubMed, Embase, and Scopus to identify studies that evaluated the effectiveness of PP implantation in treating priapism and the long-term complications, outcomes, and patients' satisfaction rate.

Results: Out of 717 English-language studies published between 2002 and 2022, 17 were chosen for this review. Majority of patients had a malleable PP (MPP) implant, either early or delayed after the priapism episode. Early placement (EP) of PP is widely defined between studies ranging from less than 72 hours, within 1 week, and within 3 weeks. Most common causes of priapism were sickle cell anemia (SCA), medication-induced, and idiopathic. Studies show a higher satisfaction rate ranging between 80% and 100%, with sexual intercourse achievement ranging between 64.2% and 100%. Based on the GRADE system, included studies rated as very low quality of evidence. Commonly reported complications that arise after PP procedures, include device infection, erosion, curvature, and mechanical malfunction, such as auto-inflation.

Conclusions: PP can be an effective treatment option for priapism, particularly in cases of ischemic priapism lasting more than 36 hours or recurrent priapism that is medically refractory. However, due to the very low quality of evidence, larger, well-designed studies are warranted where long-term outcomes, patients' satisfaction, and complications following priapism-related PP implantation are measured as endpoints.

Keywords: Priapism; penile prosthesis (PP); penile implant; PP implantation

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^ ORCID: David A. Velasquez, 0000-0001-6117-116X; Paulo Vitor Barreto Guimaraes, 0009-0003-0475-4918; Hernan Lescay, 0000-0003-4395-1028; Omer Raheem, 0009-0008-0995-8107.

Introduction

Priapism is a persistent erection of the penis in the absence of sexual stimulation that lasts greater than 4 hours. It is a rare condition with an estimated incidence rate of 1–1.5 cases per 100,000 people (1). Priapism is classified into three types: ischemic, non-ischemic, and recurrent ischemic. Priapism is associated with significant morbidity and complications, including erectile dysfunction and penile fibrosis, and often requires prompt medical and/or surgical intervention (2).

For cases of ischemic, low-flow, or veno-occlusive priapism that fail conservative treatment and shunt procedures, immediate insertion of a penile prosthesis (PP) may be the best option to preserve erectile function and prevent penile shortening due to corporal fibrosis (3). Per the American Urologic Association (AUA), immediate PP implantation is recommended for priapism episodes that last more than 36 hours and is considered the first-line treatment in ischemic priapism lasting more than 72 hours (4).

Non-ischemic, arterial, or high-flow priapism is an erection caused by unregulated cavernous arterial inflow, which does not cause rigidity or pain, and emergency treatment is typically unnecessary (5). However, long-term exposure to high oxygen levels can cause corporal fibrosis and result in erectile dysfunction. Despite the potential benefits of non-ischemic priapism in preventing fibrosis and erectile dysfunction in the short term, patients with this subtype of priapism may still require PP implantation as a last resort, typically after unsuccessful selective embolization (6).

Recurrent, stuttering, or intermittent priapism is characterized by recurrent, painful, prolonged erections that resolve spontaneously and generally last less than ischemic priapism. Medical management has demonstrated efficacy in decreasing the frequency and duration of episodes; however, in cases of medically refractory recurrent priapism, PP implantation is considered to mitigate the risk of future ischemic episodes; however, such occurrences are infrequent (7).

The surgical management of priapism presents considerable challenges influenced by various factors. Of particular significance is the scarcity of published literature concerning the optimal timing for PP implantation in priapism cases. Immediate implantation is considered to have a greater risk of infection compared to delayed implantation (8). Nevertheless, a consensus on the precise timeline distinguishing immediate, early, and delayed implantation remains elusive. Discrepancies arise from various studies, where delayed implantation is defined as occurring beyond 3 weeks, 3 months, or 4 months following the initial onset of priapism (9-11). Consequently, comparing outcomes and complication rates across these studies becomes challenging due to the substantial variations in the defined timelines. According to multiple urologic guidelines, implantation is only recommended when other less invasive treatments, like phosphodiesterase inhibitors and intracavernosal injections, have proven ineffective in treating priapism (12,13). We herein provide a systematic review that aims to evaluate PP in the management of priapism. Specifically, we will provide a descriptive, comprehensive review assessing the long-term complications, outcomes, and satisfaction rate of patients who receive PP following an episode of priapism. We present this article in accordance with the PRISMA reporting checklist (available at https://tau.amegroups.com/article/view/10.21037/tau-23-224/rc).

Highlight box

Key findings

- Penile prosthesis (PP) emerges as a promising therapeutic avenue for treating priapism, particularly in cases of ischemic priapism with a duration exceeding 36 hours or recurrent priapism resistant to medical interventions.

What is known and what is new?

- Priapism is an infrequent condition characterized by persistent penile erection lasting over 4 hours without sexual stimulation, leading to significant morbidity and complications, such as erectile dysfunction and penile fibrosis. The surgical management of priapism presents considerable challenges. Our comprehensive review aims to assess the role of PP implantation in the treatment of priapism.

What is the implication, and what should change now?

- The existing evidence on this subject is of very low quality, underscoring the need for larger, well-designed studies to investigate priapism-related PP implantation thoroughly. Such studies should evaluate long-term outcomes, patients' satisfaction, and complications as primary endpoints.

Methods

A systematic literature search in the databases PubMed, Embase, and Scopus was performed. The search terms used were "priapism" AND ("penile prosthesis" OR "penile implant" OR "penile prostheses" OR "penile prosthesis

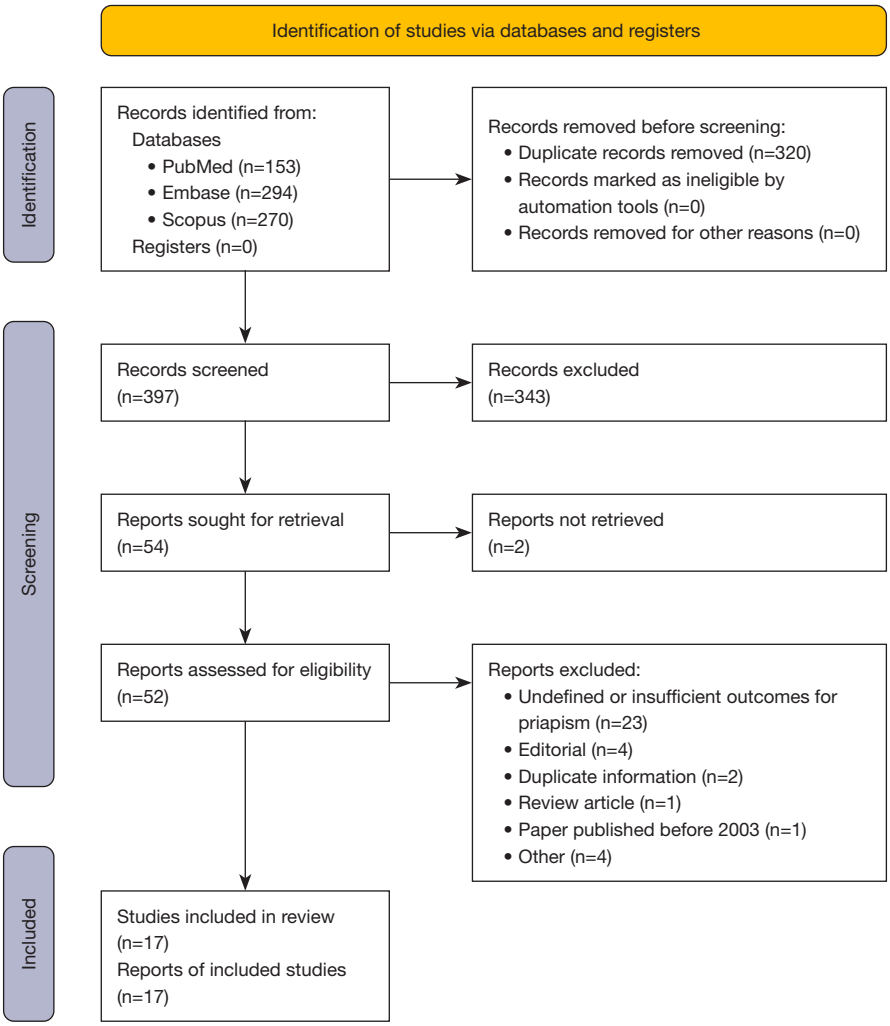

Figure 1 PRISMA flow diagram illustrating the process of study screening and selection. The diagram delineates the number of records identified, included, and excluded at each stage of the screening process.

implantation" OR "penile prosthesis implantations"). All the studies in the English language and published up to 2022 were included for evaluation.

The PRISMA statement was followed. Criteria for the exclusion of the studies were: case report studies, number of patients <5 cases, expert opinions, comments, letters to the editor, non-English language, experimental studies in animals, papers that only describe techniques, and studies in population with no priapism previously to the PP implantation. Two reviewers independently screened each record.

The measured outcomes included satisfaction rate, sexual intercourse achievement, and penile length. The reasons for exclusion are presented in the flow diagram (*Figure 1*). Regarding the quality of the studies, all the included papers were rated based on the GRADE system.

Results

A total of 717 English-language studies were collected of which 17 were selected for this review from 2002 to 2022. The reasons for exclusion are described in *Figure 1*. According to the GRADE system, the included studies have a very low quality of evidence.

The outcomes of penile prostheses implantation are summarized in *Table 1*. Most of the studies describe the outcomes of an early PP implant; however, Durazi *et al.* describe the results in a delayed approach to PP implant,

Table 1 Included papers with summarized results

Author, year	N and age (years)	Surgical technique	Etiology priapism	PP device	Operative time	Follow-up	Intraoperative complications	Post-operative complications	Outcomes
Salman, 2023 (8)	N: 42; EP: 23; DP: 19 Age: EP: 55±9.5; DP: 54±13	EP: <1 week DP: ≥3 months	SC anemia [6]; drugs [15]; idiopathic [17]; other [4]	AMS spectra implant or TUBE malleable implant	N/R	EP: 11±5.5 months DP: 15±4.5 months	EP: N/R DP: corporal perforation [7]	Distal erosion (P<0.005): EP [2]; DP: [0] Infection: EP [4]; DP [2] Penile edema (P<0.005): EP [6]; DP [0]	Implant length: EP: 22±1 cm; DP: 20.7±1 cm Implant girth: EP: 11±0.5 mm; DP: 10±0.7 mm
Johnson, 2019 (9)	N: 126; EP: 88; DP: 38 Age: N/R	EP: <3 weeks; MPP [83]; IPP [5] DP: >3 weeks; MPP [19]; IPP [19]	N/R	N/R	N/R	EP: median 17.8 [3–76] months DP: median 18.6 [3–28] months	N/R	EP: infection [7]; curvature [1]; erosion [1] DP: infection [9]; erosion [2]; mechanical failure [1]	EP: >90% achieved sexual intercourse; >90% satisfaction rate DP: 86.8% achieved sexual intercourse; 60.5% satisfaction rate
Zacharakis, 2014 (10)	N: EP: 68; DP: 27 Age: EP: mean 42 [26–63]; DP: mean 45 [28–69]	EP: MPP [64]; IPP [4] DP: MPP [12]; IPP [15]	SC anemia [39]; medication [27]; idiopathic [29]	N/R	N/R	EP: median 17 [15–24] months DP: median 21 [20–24] months	N/R	EP: infection [5]; curvature [1] DP: infection [5]; erosion [1]; mechanical failure [1] Penile shortening: EP: 3%; DP: 40% P<0.001	EP: easier dilation; satisfaction rate >90% DP: satisfaction rate 60% P<0.001
Elhawy, 2021 (11)	N: 72 Age: 41.2±17.4	MPP [2] EP [8] DP [16]	Medication [38]; idiopathic: 34	Genesis, coloplast	N/R	Median 43 [38–64] months	N/R	Glans edema: EP [3]; DP [1] Wound infection: EP [4]; DP [3] Post-operative pain: EP [3]; DP [1] Distal fibrosis: EP [0]; DP [1] P>0.05	EP: median girth 11 mm; median hospital length 3 days DP: girth median 9.5 mm; median hospital length 1 day
Durazi, 2008 (14)	N: 17 Age: median 22 [18–28]	DP: MPP [11]; two-piece IPP [4]; three-piece IPP [2]	SC anemia [16]; medication [1]	MPP (AMS 650) Two-piece (Ambicor) Three-piece (700CX)	N/R	Median 6 [2–9] years	Urethral injury [2]	Penile edema [4]; superficial hematoma [3]	100% satisfaction rate; penile length median 16 [14–20] cm
Ralph, 2009 (15)	N: 50 Age: mean 46 [25–73]	EP: MPP [43], three-piece IPP [7]	SC [5]; medication [18]; Idiopathic [24]; other [3]	MPP: Genesis and Acuform; Coloplast; AMS 650 IPP: AMS CX 700	N/R	Median 15.7 [4–60] months	N/R	Infection [3]; distal erosion [3]; short rods distal [2]; auto-inflation [1]	96% satisfaction rate; no patient complained of penile shortening
Zacharakis, 2015 (16)	N: 10 Age: mean 41.3 [26–58]	Early insertion MPP Posterior exchange to IPP	N/R	MPP (Coloplast Genesis) IPP (AMS 700 or Coloplast Titan)	N/R	Median 13.5 [3–24] months	N/R	Pump malfunction [1]; mild curvature [1]	80% satisfaction rate after MPP, and 90% after IPP; exchange with upsizing of cylinders by a median of 1 cm in either one or both corporal bodies (range, 0–3 cm)
Razzaghi, 2010 (17)	N: 14 Age: mean 44 [29–55]	Early MPP	N/R	N/R	N/R	Median 13.9 [11–38] months	N/R	N/R	100% satisfaction rate; 64.2% achieved sexual intercourse; no penile shortening
Nic an Ríogh, 2019 (18)	N: 6 Age: 37–63	Early insertion: MPP	Drugs [5]; malignancy [1]	N/R	N/R	N/R	N/R	N/R	100% achieved sexual intercourse
Rees, 2002 (19)	N: 8 Age: mean 41 [27–58]	Early implant: MPP [6]; IPP [2]	SC [1]; medication [4]; idiopathic [3]	MPP Acuform IPP AMS 700CX	N/R	Mean 17 [5–35] months	N/R	Penile deformity due to fibrosis [1]	100% satisfaction rate and achieved sexual intercourse; no penile shortening
Salem, 2010 (20)	N: 12 Age: N/R	Early MPP	SC anemia [1]; medication [7]; idiopathic [4]	N/R	N/R	Median 15 [6–36] months	Proximal corpora perforation [1]	N/R	100% achieved sexual intercourse
Uberoi, 2011 (21)	N: 8 Age: mean 35.9 [18–52]	Three-pieces IPP [7]; MPP [1]	SC anemia [2]; medication [3]; idiopathic [3]	N/R	Mean 85 min	2–57 months	N/R	N/R	87.5% satisfaction rate
Vagnoni, 2019 (22)	N: 6 Age: mean 41 [18–47]	Early implant soft-silicone PP	SC [2]; idiopathic [4]	Soft-silicone PP Virilis I™	Median 82 [62–180] min	Median 9 [3–17] months	N/R	Transient reduction of penile sensitivity	100% satisfaction rate; no significant loss of penile length or penile curvature

Table 1 (*continued*)

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Author, year	N and age (years)	Surgical technique	Etiology priapism	PP device	Operative time	Follow-up	Intraoperative complications	Post-operative complications	Outcomes
Sedigh, 2011 (23)	N: 5 Age: median 56 [33–73]	Early insertion: IPP [4]; MPP [1]	N/R	Coloplast Titan OTR [1] AMS 700 LGX [1] AMS 700 CX [1] AMS (MPP)	94± 31.3 min	N/R	Penile hematoma [5]	Initial reduced penile sensibility [5]; no infection or erosion	IIEF-5: Q5 mean value 4; 100% achieved sexual intercourse; No penile shortening
Baumgarten, 2018 (24)	N: 18 Age: mean 43.9 [0–62]	MPP [16]; IPP [2]	N/R	N/R	N/R	Mean 4.8 [1–36] months	N/R	Infection [4]	83% satisfaction rate
Bella, 2012 (25)	N: 7 Age: N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	EHS: 4 at 6 months; IIEF-5 increased over 17 points (mean) from the baseline
Hawksworth, 2019 (26)	N: 19; EP: 2; DP: 17 Age: mean 41 [21–86]	EP [2] DP [17]	N/R	N/R	N/R	N/R	N/R	EP: 1 infection with PP removal	7 answered EDITS questions: 6 were satisfied (85.7%)

A comprehensive overview of studies focusing on PP implantation post-priapism. The table lists key study details including author and year, sample size (n), surgical technique timing, etiology of priapism, type of PP device used, operative time, follow-up duration, intraoperative and postoperative complications, and overall patient outcomes. Data are presented as mean ± SD, [number], mean [range], or median [range]. N, number; PP, penile prosthesis; EP, early placement; DP, delayed placement; SC, sickle cell; N/R, not reported; MPP, malleable penile prosthesis; IPP, inflatable penile prosthesis; EHS, erection hardness score; EDITS, erectile dysfunction inventory of treatment satisfaction; SD, standard deviation.

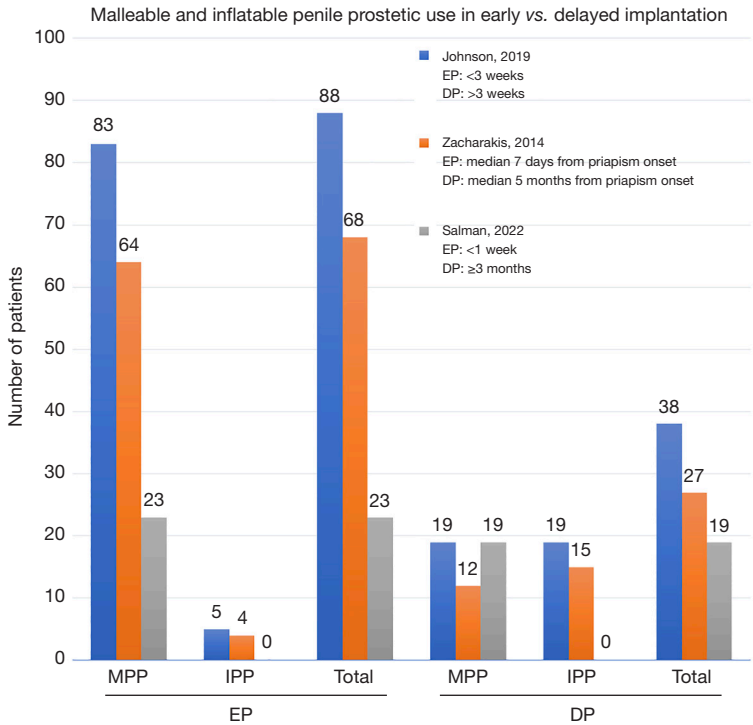

Figure 2 Comparison of MPP and IPP use in early *vs.* delayed implantation: this bar graph presents the number of cases for early (<3 weeks) *vs.* delayed (>3 weeks) implantation of PPs based on data from various studies. MPP, malleable penile prosthetic; IPP, inflatable penile prosthetic; EP, early placement; DP, delayed placement; PP, penile prosthetic.

and some of the papers do not specify the time when the prosthesis was implanted (early or delayed) (9-12,14). Of these selected papers, five compare the outcomes of early placement (EP) *vs.* delayed placement (DP) PP implants after priapism (8-11,26).

Various researchers' approaches to EP of penile implants are elucidated. Johnson [2019] conducted a study with a sample size (n) of 126 participants and defined the EP group as comprising 70% of the total patients, wherein surgery took place within 3 weeks of the priapism incident (9). Conversely, Elhawy [2021] investigated 24 individuals receiving malleable PP (MPP), accounting for 33% of the cohort, and considered EP to entail implantation after 72 hours, with a median implantation time of 7 days (11). Additionally, in a study conducted by Zacharakis [2014] with a sample size of 68 participants (n=68; 100%), EP was defined similarly to Elhawy's approach (10,11). Finally, Salman [2023] undertook research with a sample size of 42 participants, accounting for 55% of the total, and classified EP as implantation during the first week following the occurrence of priapism (8). *Figure 2* shows the frequency of MPP and inflatable PP (IPP) in the EP or DP settings, as described by Johnson, Zacharakis, and Salman (8-10).

The most common causes of priapism described in all papers are sickle cell anemia (SCA), the use of medication (primarily injectable drugs, to achieve an erection), and idiopathic. Nic an Ríogh [2019] described one case of priapism due to malignancy. Overall studies show a higher satisfaction rate ranging between 80% and 100% compared to baseline, with sexual intercourse achievement ranging between 64.2% and 100% (9,14-20).

Most of the patients had a MPP implant either early or delayed after the priapism episode, *Figure 3* shows the relation between the number of IPP and MPP in the different papers. Only two studies used a higher number of IPP compared to MPP—Uberoi *et al.* of a series of eight patients, seven had a three-piece IPP implant, and only one had an MPP (8,14-16,21,22) and Sedigh *et al.* had only one MPP implant *vs.* four IPP (23). Zacharakis *et al.* [2015] describe a series of 10 patients with early MPP implant after priapism with later exchange to IPP (16). This protocol showed upsizing of cylinders by a median of 1 cm in both

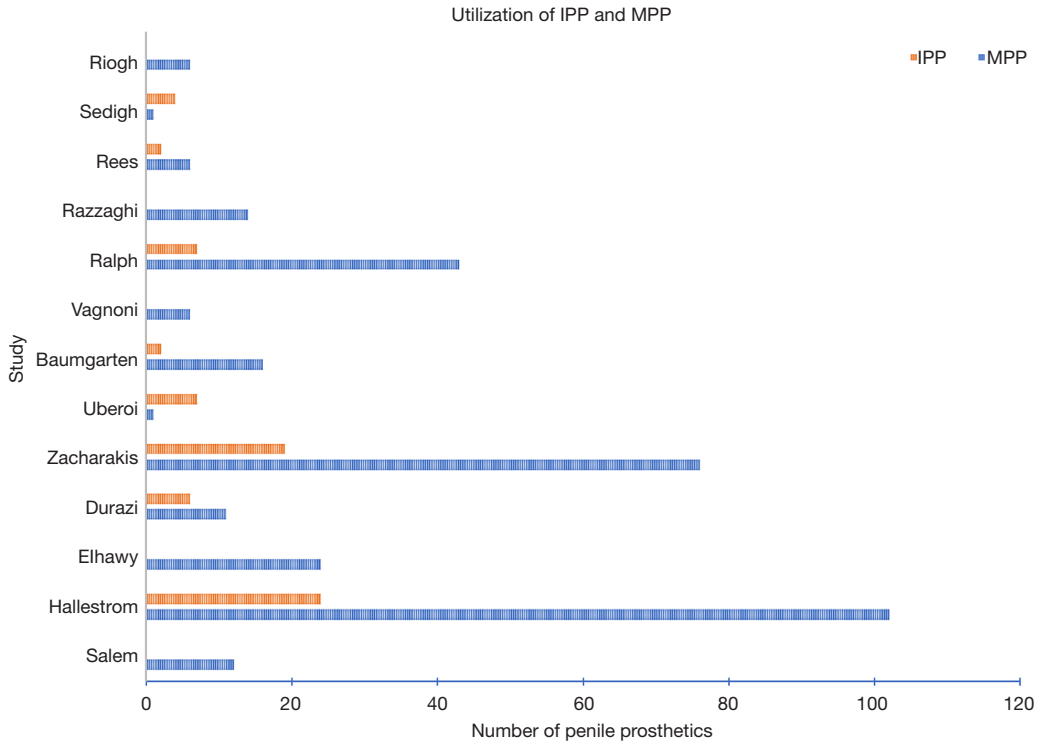

Figure 3 Utilization of IPP and MPP across studies. IPP, inflatable penile prosthesis; MPP, malleable penile prosthesis.

corporal bodies (range 0–3 cm), and two complications (one pump malfunction, and mild curvature) (16).

The majority of studies examining the occurrence of penile shortening after priapism have not found evidence to support this phenomenon (15,17,19,22,23). However, Zacharakis [2014] reported this complication in his series, and it was observed more frequently in patients who underwent DP implants compared to those who received early implants (40% *vs.* 3%, P<0.001) (10).

Elhawy *et al.* compared the median girths between patients who underwent EP insertion and those who received DP insertion. The median bending for the EP group was 11 mm, while for the DP group, it was 9.5 mm (11). The study also examined the occurrence of complications in these groups. Although the EP group had a higher number of gland edema, wound infection, and post-operative pain, the DP group had a higher incidence of distal fibrosis. However, none of these differences were statistically significant.

The most frequently reported complications following PP procedures include infection (range, 6–50%), erosion (range, 1–9%), curvature (range, 1–10%), and mechanical issues with the device, such as malfunction or auto-inflation (range, 2–5%) (8-11,14-16,19,24,27). Sedigh [2011] and Vagnoni [2019] found that all patients initially experienced a decrease in penile sensitivity, but this was a temporary side effect (22,23).

The majority of studies did not employ validated questionnaires to assess sexual function outcomes and only relied on descriptions of patient satisfaction, reported as percentages (range, 60–100%) (9-11,14-17,21-24). However, Bella *et al.* used the IIEF-5 to evaluate patients and demonstrated a significant increase of over 17 points (mean) from the baseline in sexual function after the penile implant post-priapism event (25).

Discussion

Priapism is a rare but potentially serious condition that causes prolonged and painful erections. It is typically classified into three types, ischemic, non-ischemic, and recurrent with the former being the most common form. Initial management of ischemic priapism typically involves aspiration and irrigation of the corpora cavernosa with sympathomimetic agents. However, if this fails, invasive treatments such shunts and surgical interventions may

be necessary. Implantation of a PP is the most effective treatment for post-priapism erectile dysfunction. It can be performed in an immediate or delayed fashion with an IPP or MPP. In this review, we aimed to evaluate the characteristics of patients who underwent PP insertion for the treatment of refractory ischemic priapism.

Placing a PP during the delayed setting may pose a significant challenge due to the presence of widespread fibrosis in the corpora. Expanding the corpora requiring extended corporotomies and the use of special tools increases the likelihood of complications such as distal/proximal crossover, perforation, or urethral injury. Additionally, the procedure's duration significantly increases the risk of postoperative infection compared to first-time implants (28).

The patient-reported satisfaction rates were observed to be more favorable among individuals who underwent IPP insertion, ranging from 80% to 100%, compared to those who received MPP with satisfaction rates ranging from 60.5% to 100%. However, it is noteworthy that several studies lacked a standardized approach in assessing patient satisfaction rates (9-11,14-16,21-24,27). Furthermore, as extensively documented in the literature, patients with priapism face a heightened risk of infection, erosion, and contracture in comparison to individuals with no prior history of erectile dysfunction (28). Penile deformity is a known complication with IPP insertion in the acute setting and has been postulated to be from contracture of the corporal scarring on a deflated cylinder (28,29). In the delayed setting, patient satisfaction was lower and presented the surgeon with a higher degree of operative difficulty given the fibrosis and scarring that occurs over time. Furthermore, fibrosis tends to cause some degree of penile shortening, and patients may still experience a loss of length after implantation, which is one of the most reported reasons for dissatisfaction among men with a PP. Given the low patient satisfaction rates, it has been recommended to perform PP implantation in the acute setting (26,27,29,30). It should be noted that no studies reviewed were powered to demonstrate a superiority of immediate *vs.* delayed implantation, and thus any conclusion is merely based on available published evidence.

While the available evidence suggests that PP insertion is a safe and effective option for managing priapism, there are some limitations to consider. Firstly, these procedures are invasive and may carry risks such as infection, device malfunction, and erosion. Additionally, the long-term effects of these devices on sexual function and patient satisfaction are not well understood. Further research is needed to better understand the optimal patient selection, device selection, and postoperative care protocols for IPP and MPP insertion in the management of priapism.

Conclusions

The purpose of this review is to evaluate the characteristics and outcomes of patients undergoing treatment for ischemic priapism with insertion of a PP. Studies specifically looking at delayed *vs.* immediate implantation of PP are limited. Also, to date there are no trials comparing IPP *vs.* MPP insertion for ischemic priapism. Until more data is available, clinical management of ischemic priapism with prosthesis insertion should be approached as a shared decision-making process. Counseling should include the increased risk of infection and erosion in these patients as well as concern for penile shortening in the delayed setting.

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Footnote

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appropriately investigated and resolved.

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