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Review

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Non-invasive and surgical penile enhancement interventions for aesthetic or therapeutic purposes: a systematic review

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Objective

To systematically review the literature in order to investigate the efficacy and safety of surgical and non-invasive penile enhancement procedures for aesthetic and therapeutic purposes.

Methods

A systematic search for papers investigating penile enhancement procedures was performed using the MEDLINE database. Articles published from January 2010 to December 2019, written in English, including >10 cases, and reporting objective length and/or girth outcomes, were included. Studies without primary data and conference abstracts were excluded. The main outcome measure was objective length and/or girth improvement. The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

Results

Out of 220 unique records, a total of 57 were reviewed. Eighteen studies assessed interventions for penile enhancement in 1764 healthy men complaining of small penis. Thirty-nine studies investigated 2587 men with concomitant pathologies consisting mostly of Peyronie's disease and erectile dysfunction. Twenty-five studies evaluated non-invasive interventions and 32 studies assessed surgical interventions, for a total of 2192 and 2159 men, respectively. Non-invasive interventions, including traction therapies and injection of fillers, were safe and mostly efficacious, whereas surgical interventions were associated with minor complications and mostly increased penile dimensions and/or corrected penile curvature. Overall, the quality of studies was low, and standardized criteria to evaluate and report efficacy and safety of procedures, as well as patient satisfaction, were missing.

Conclusion

The quality of the studies on penile enhancement procedures published in the last decade is still low. This prevents us from establishing recommendations based on scientific evidence regarding the efficacy and safety of interventions that are performed to increase the penis size for aesthetic or therapeutic indications.

Keywords

penis surgery, penile augmentation, penile enlargement, penile lengthening, penile straightening, erectile dysfunction, penile curvature, penile prosthesis, #erectiledysfunction, #Andrology

Introduction

Penile enhancement interventions have been one of the hottest and most controversial topics in the field of reconstructive urology and andrology for decades [1]. Currently, these procedures are mainly recommended for men with sexual dysfunction caused by anatomical abnormalities, such as Peyronie's disease (PD) [2]. However, aesthetic concerns lead many men with an average-sized penis to seek penile augmentation [3,4].

Unfortunately, the long history of penile enhancement techniques has not been followed by a concomitant increase in high-quality research on their efficacy and safety, which are still poorly supported by scientific evidence [2,5]. Although some studies claim an effective lengthening or enlargement of the penis, a large part of the scientific literature suggests poor efficacy as perceived by patients and a worrisome associated risk of complications such as penile deformity, erectile dysfunction (ED), sensory loss and infection [5–7]. The efficacy of these interventions in the aesthetic setting is often overshadowed by the reported satisfaction levels of patients, who tend to consider the augmentation insufficient, probably because of a mistaken construct of the ideal penile size [8]. This might have contributed to the decreasing trend in the number of procedures worldwide reported by the International Society of Aesthetic Plastic Surgery [9].

The dearth of evidence on the efficacy and safety of interventions for penile enhancement also results in limited guidance on their use, which is typically constrained to procedures for the treatment of anatomical abnormalities such as PD [2]. In addition, guidelines acknowledge the limited ability of the available literature to answer important questions such as the ideal material and procedure for inserting grafts to reduce the risk of complications, including ED [2]. Finally, the greater interest of the scientific community for the pathological setting is reflected in the burden of the literature. It tends to focus more on interventions performed for patients with concomitant penile pathologies [7,10,11] than healthy men [6] for aesthetic purposes. Overall, this scenario leaves clinicians and surgeons, particularly those attending patients in the aesthetic setting, with very limited resources for making decisions on the adequate therapeutic approach to each patient profile.

The primary aim of the present study was to conduct a systematic review of the literature in order to investigate the efficacy of surgical and non-invasive interventions of penile enhancement for aesthetic and therapeutic purposes. The secondary aim of the review was to evaluate the safety of these procedures in the same settings.

Material and Methods

Search Strategy

A computerized bibliographic search on the MEDLINE database was conducted in January 2020 to identify studies investigating non-invasive and surgical interventions aiming to increase penile length and/or girth in healthy men and men with concomitant pathologies associated with sexual dysfunction.

The search was performed using the general terms 'stretching', 'enlargement', 'lengthening', 'thickening', 'augmentation', 'enhancement', 'extender', 'vacuum', 'small', 'traction', 'extension', 'dysmorphophobia', 'shortening', 'shortened', and 'elongation', connected with the OR, and the terms 'penis' and 'penile' connected with the OR. The two strings were combined with the AND. The search was limited to the appearance of the terms in the title. Reference lists of the retrieved articles were used to identify any other relevant study.

We focused only on recent studies, limiting the research to studies of the last 10 years, published from January 2010 to December 2019.

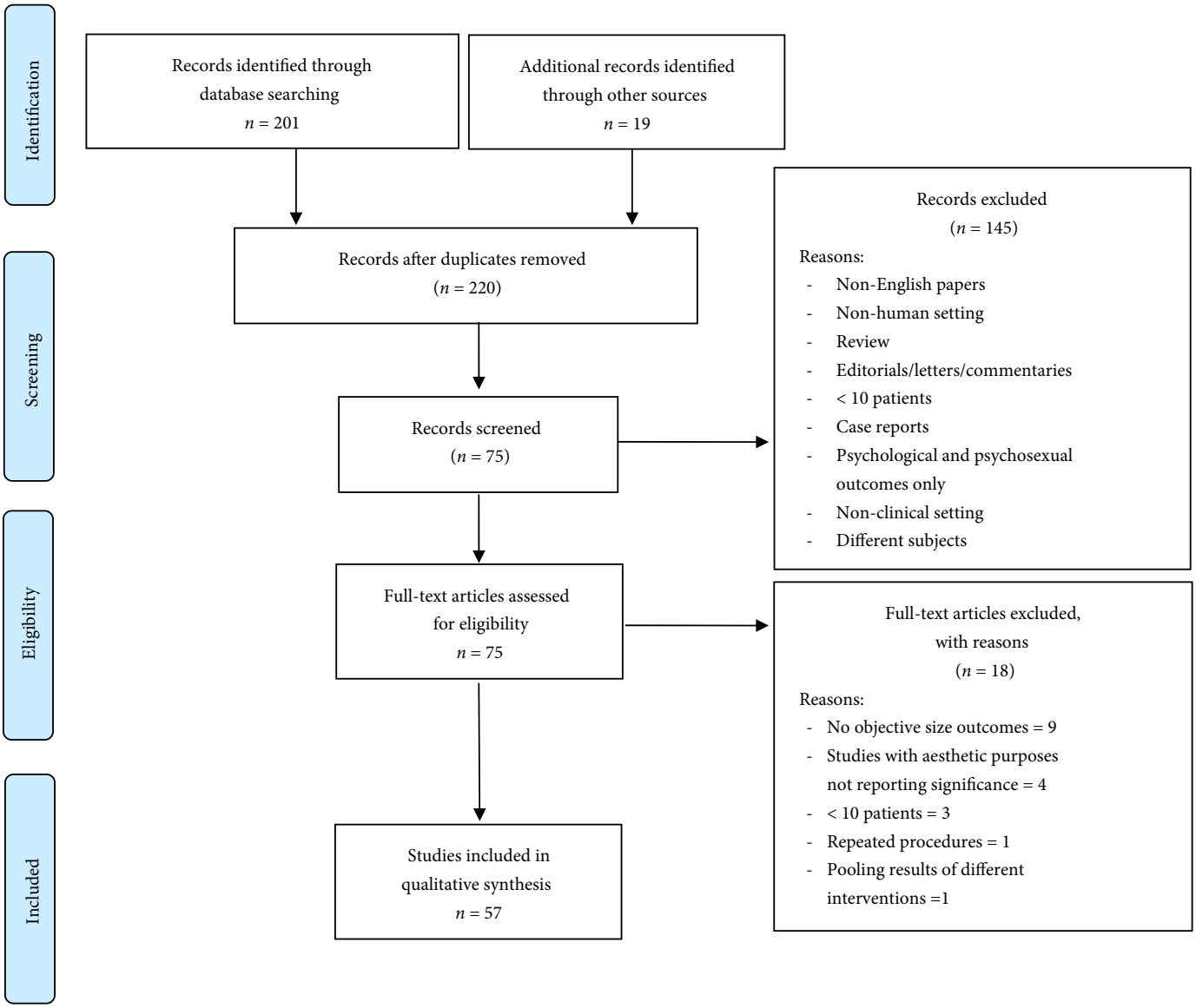
Study Selection

The review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [12]. The Population, Intervention, Comparator, Outcome (PICO) model was used in order to define study eligibility. Papers were deemed eligible if they assessed patients with a normal penis or concomitant penile disorders (P), undergoing non-invasive or surgical interventions of penile enhancement (I) to determine the efficacy on penile length and/or girth of these procedures (O). The comparison parameter (C) was not present in the PICO analysis.

Two authors (C.M., P.V.) performed the initial screening of titles and abstracts independently to determine which papers could potentially meet the inclusion criteria. Subsequently, they subjected the full-text articles to a more exhaustive assessment. A third author (J.R.O.) resolved all discrepancies.

The review included human studies written in English, including >10 patients, reporting objective length outcomes for lengthening interventions and girth outcomes for enlargement interventions, and, for studies with aesthetic purposes, reporting comparisons with statistical methods. Studies without primary data (i.e. reviews, commentaries and letters), and conference abstracts were excluded (Fig. 1).

Fig. 1 PRISMA flow diagram for the literature search.



Data Extraction and Outcomes Measures

Two authors (C.M., F.C.) extracted data independently. The data collected included data source, eligibility, methods, patient characteristics, interventions, and results. In case of disagreement despite further discussion between the two authors, a third author (J.R.O.) arbitrated. The main outcomes recorded were change in penile dimensions (length and girth), the primary efficacy outcome of this study, and complications. Changes in length were recorded when measured as flaccid penile length (FPL), stretched penile length (SPL), and/or erect penile length (EPL). Other efficacy outcomes were also retrieved, including the erect penile curvature (EPC), erectile function (EF) or sensitivity changes, volumes of tissue fillers injected, traction or vacuum device use, and operating times.

Data were summarized as reported in the original study, and no meta-analyses or data transformation were performed.

Results

Studies Included

This review included a total of 57 studies [13–69] assessing interventions for penile lengthening and/or enlargement in 1764 healthy men complaining of a small penis (18 studies) [13–30] and 2587 men with concomitant penile pathologies

(39 studies) [31–69] consisting mostly of PD and ED. Of the 57 studies included in the review, 25 assessed non-invasive interventions [13,17–24,31–44,68,69] and 32 evaluated surgical procedures [14–16,25–30,45–67], for a total of 2192 and 2159 men, respectively.

Efficacy outcome measures included in these studies were changes in length, measured as FPL, SPL and/or EPL, and changes in penile circumference (or girth). Length and girth were most commonly measured using either a tape measure or a rigid ruler and a tape measure or a caliper, respectively. The length was most commonly measured on the dorsal surface from the penile base (pubo-penile junction) to the tip of the glans (meatus), whereas girth was most commonly measured in the flaccid state at one or more levels along the penis shaft. More specifically, these two measuring methods were explicitly described in 48 [13–22,25–36,38–53,60–69] and 39 papers [13–25,27,31–42,44,48,54,60–69], respectively.

Studies in patients with pathologies such as PD also evaluated the correction of the penile curvature, measured as EPC [31–36,38,39,46–53,55], typically after pharmacologically induced erection or with auto-photography of the erection. In studies involving surgical procedures for PD and ED [45,48,49,52–56,58,60–62], change in EF was a particularly relevant outcome, which was assessed using a variety of questionnaires, such as the International Index of Erectile Function (IIEF) or its shortened five-item version (IIEF-5) [70,71].

Of the 57 papers included, 51 [1–17,19–20,22–33,36–43,45–67,69] reported safety outcomes (complications).

Penile Enhancement for Aesthetic Purposes

A total of 18 studies [13–30] investigated non-invasive (nine papers) [13,17–24] and surgical (nine papers) [14–16,25–30] interventions for men complaining of a small penis, aiming to increase length or girth alone or simultaneously.

Six of the 18 studies [13,14,17,19,26,27] used a single examiner to measure the penile dimensions in order to avoid interpersonal variability, whereas the remaining studies did not report any precautions taken to ensure consistent measurements.

Changes in EF were assessed using validated instruments (i.e. IIEF) in one and three studies evaluating non-invasive and surgical interventions, respectively [13–16]. Satisfaction was evaluated inconsistently, using self-developed rating scales or available questionnaires, such as the Male Sexual Quotient (MSQ) [72], a visual analogue scale (VAS) [73], the unvalidated Augmentation Phalloplasty Patient Selection and Satisfaction Inventory (APPSSI) [74], the validated Male Genital Self-Image Scale (MGSIS) [75], and Self-Esteem and Relationship (SEAR) questionnaire in ED [76].

Non-invasive Interventions for Aesthetic Purposes

The non-invasive interventions aiming to increase penile length or penile circumference consisted of using penile extenders or injecting filling substances, respectively (Table 1).

Two studies assessed the efficacy and safety of penile traction therapy (PTT) using penile extenders for the management of men complaining of a small penis, for a total of 77 men evaluated [17,18]. Both studies reported significant ($P < 0.05$), albeit modest (<2 cm), increases in baseline FPL and SPL, which were more prominent during the first 3 months of treatment and were maintained after extended follow-up, with few minor complications. Accordingly, participant self-reporting showed modest treatment satisfaction. Even though IIEF-5 outcomes were not fully reported, EF improved in 64.7% and 50% of the patients with mild or mild-to-moderate ED at baseline, respectively [17].

The efficacy and safety of tissue fillers in increasing penile girth was evaluated in seven studies, including a randomized uncontrolled trial, for a total of 946 men. These papers assessed different tissue fillers, including autologous fat (one study) [13], polylactic acid and/or hyaluronic acid (three studies) [19–21], and different combinations with polymethylmethacrylate (PMMA) microspheres (three studies) [22–24]. The volumes of the fillers used differed according to the substances, with mean volumes of 20 mL for polylactic acid and hyaluronic acid-based fillers, 23.7–40 mL for PMMA-based fillers, and 36.5 mL for autologous fat. Injection techniques were similar, and most studies injected the fillers between the Dartos and Buck's fascia. Overall, all studies reported statistically significant ($P < 0.05$) changes in penile girths, with ranges of 1.7–3.92 cm, 1.35–2.7 cm, 2.4–4.2 cm and 3 cm for hyaluronic acid, polylactic acid, PMMA and autologous fat, respectively, at different post-treatment time points and shaft levels. The increases were maintained during the follow-up period, which ranged from 6 to 18 months post-treatment in most studies. Complications were mostly transient, with the exception of penis irregularities appearing after PMMA injection, which occasionally required surgical removal [22]. Most participants were satisfied and did not report erectile or sensitivity changes, with the exception of one study reporting a slight decrease of tactile sense in most patients after injection of a hyaluronic acid-based gel [21].

Surgical Interventions for Aesthetic Purposes

Dissection of the suspensory ligament (ligamentolysis) was investigated alone in one study [25], and in four papers in combination with other techniques aiming to increase penile girth concomitantly using free dermal fat graft insertion (three studies) [26–28], and autologous fat transfer (one

Table 1 Studies investigating non-invasive interventions of penile enhancement for aesthetic purposes.

Authors	Study design/ Follow-up/ Sample size	Age, mean (range), years	Intervention	FPL		SPL		EPL		Girth		Efficacy summary	Safety summary
				Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
Lengthening													
Nowroozi et al., 2015 [17]	Obs. Follow-up 6 months (n = 54) patients	30.1 (23–40)	AndroPenis® 4–6 h/day for 6 months	8.6 (1.0)	9.4 (1.3) (1 months) 10.1 (1.4) (3 months) 10.3 (1.4) (6 months) 10.0 (1.4) (9 months)	11.2 (1.3)	12.0 (1.4) (1 months) 12.2 (1.5) (3 months) 12.4 (1.5) (6 months) 12.4 (1.5) (9 months)	12.9 (1.4)	13.8 (1.2) (1 months) 14.2 (1.3) (6 months)	9.6 (1.1)	9.8 (1.1) (3 months)	FPL and SPL: significant increase at 3 months and between 3 and 6 months (albeit negligible) EPL: significant increase at 6 months Girth: non-significant increase	Pain, n = 2 Numbness, n = 1 Bruising, n = 1
Nikoobakht et al., 2011 [18]	Obs. Follow-up 3 months (n = 23)	26.5 (17–60)	Golden Erect® 4–6 h/day for 2 weeks 9 h/day thereafter up to 3 months	8.8 (1.2)	10.1 (1.2) (1 months) 10.5 (12) (3 months)	11.6 (1.1)	12.4 (1.4) (1 months) 13.3 (1.5) (3 months)	NA	NA	Proximal: 10.6 (1.1) Glans: 9.2 (0.8)	Proximal: 10.7 (0.8) (1 months) 10.4 (0.7) (3 months) Glans: 9.4 (0.9) (1 months) 8.8 (0.7) (3 months)	FPL and SPL: significant increase at 1 and 3 months, and between 1 and 3 months Glans girth: significant decrease between 1 and 3 months	NA
Enlargement													
Yang et al., 2019 [19]	RUT follow-up 48 weeks (n = 72)	NA (20–65)	Injection with HA n = 36 PLA n = 36	NA	NA	NA	NA	NA	NA	HA group: 8.4 (NA) PLA group: 8.08 (NA)	HA group: 11.64 (4 weeks) 11.47 (12 weeks) 11.02 (24 weeks) 10.56 (48 weeks) PLA group: 10.20 (4 weeks) 10.20 (12 weeks) 9.89 (24 weeks) 9.81 (48 weeks)	Significant increase in penile girth at 24 and up to 48 weeks with both HA and PLA fillers	Mild and transient: HA group: injection site induration, n = 1 PLA group: injection site inflammation, n = 1 penile swelling, n = 1 penile pain, n = 1
Yang et al., 2017 [20]	Obs. follow-up 18 months (n = 23)	50.5 (31–62)	Injection with PLA	NA	NA	NA	NA	NA	NA	Proximal: 8.3 (0.8) Mid: 8.1 (0.9) Distal: 8.0 (1.0)	Proximal: 10.5 (1.1) 3 months 10.0 (0.9) 18 months Mid:	Significant increase in proximal, mid, and distal-shaft girth at 3 and	Mild and transient: injection site induration, n = 2

Table 1 (continued)

Authors	Study design/ Follow-up/ Sample size	Age, mean (range), years	Intervention	FPL		SPL		EPL		Girth		Efficacy summary	Safety summary
				Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
											10.8 (1.2) 3 months 10.4 (1.0) 18 months Distal: 10.6 (1.2) 3 months 10.2 (1.2) 18 months	18 months post-treatment.	injection site inflammation, *n* = 1 painful erection, *n* = 1 penile curvature, *n* = 1 penile erythema, *n* = 1
Casavantes et al., 2016 [22]	Obs. follow-up 7 years (*n* = 729)	37 (19–68)	Injection with PMMA microspheres 10–30% suspension	9.8 (NA)	10.5 (NA)	NA	NA	NA	NA	(*n* = 203) Base: 10.7 (1.5) Mid-shaft: 10.5 (1.5) Neck: 10.2 (1.4)	(*n* = 203) Base: 13.0 (1.5) Mid-shaft: 12.8 (1.4) Neck: 12.2 (1.6)	Significant increase in girth at base, mid-shaft and neck post-treatment.	Transient postoperative swelling and internal inflammation, n: NA. Minimum to severe irregularities (single or multiple nodules, hard ridges, micro-nodules at the entry points, indentations, or voids), n: NA (52%) Surgical removal of PMMA nodule, *n* = 3 (0.4%)
Yang et al., 2013* [23] Kim et al., 2015* [24]	Obs. follow-up 18 months (*n* = 20)	44 (IQR 20–70)	Injection with Lipen–10®: 75% cross-linked dextran 15% PMMA 10% hypromellose solution	3.6 (1.8)	5.8 (1.5) (6 months) 6.6 (1.6) (12 months) 6.6 (1.2) (18 months)	NA	NA	NA	NA	Proximal: 7.2 (0.8) Mid: 7.1 (0.8) Distal: 7.1 (0.8)	Proximal: 10.9 (1.1) (6 months) 10.8 (NA) (12 months) 10.4 (0.9) (18 months) Mid: 11.3 (0.9) (6 months) 11.4 (NA) (12 months) 11.0 (0.8) (18 months) Distal-shaft: 10.8 (1.1) (6 months) 11.3 (NA) (12 months) 10.6 (1.4) (18 months)	Significant increase in proximal, mid, and distal-shaft girth at 6, 12 and 18 months post-treatment. Significant increase in FPL at 6 months post-treatment compared to baseline, maintained at 12 and 18 months.	Mild and transient penile oedema, *n* = 20 Mild: Asymmetry, *n* = 1 (corrected with additional injection) 5-mm nodule at the injected site, *n* = 1, observed at 6 months, persisting at 12 and 18 months

Table 1 (continued)

Authors	Study design/ Follow-up/ Sample size	Age, mean (range), years	Intervention	FPL		SPL		EPL		Girth		Efficacy summary	Safety summary
				Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
Kang et al., 2012 [13]	Obs. follow-up 6 months (n = 52)	42.2 (22–56)	Injection of autologous fat from: Lower abdomen, n = 6 (11.6%) Bilateral thighs, n = 42 (80.8%) Both, n = 4 (7.7%)	7.21 (1.2)	7.22 (1.2)	NA	NA	11.72 (2)	11.65 (2.1)	Proximal: 7.01 (0.4) distal: 7.06 (0.4)	Proximal: 9.29 (0.8) distal: 9.34 (0.9)	Significant increase in proximal and distal-shaft girth	Nodular fat n = 1, (1.92 %).
Kwak et al., 2011 [21]	Obs. Follow-up 18 months (n = 50)	42.5 (27–61)	Injection with HA gel	NA	NA	NA	NA	NA	NA	7.48 (0.4)	11.41 (0.3) (1 months) 11.26 (0.3) 18 months	Significant increase in penile girth at 1month post-treatment, maintained after 18 months	NA

*EPL, erect penile length; FPL, flaccid penile length; HA, hyaluronic acid; mo, month; NA, not available; Obs., observational; PLA, polylactic acid; PMMA, polymethylmethacrylate; RUT, randomized uncontrolled trial; SPL, stretched penile length. *Same study but short-term efficacy and tolerability and long-term outcomes were presented separately.*

study) [14]. Penile enlargement was investigated alone in four studies; it consisted of surgical techniques based on graft (three studies) [16,29,30] or flap (one study) [15] implantation after penile degloving (Table 2). It is important that ligamentolysis only improves penile size in the flaccid state and, if performed alone, does not have an impact on improving penile girth.

Dissection of the suspensory ligament by incisions in the lower abdomen or by coronal incision resulted in similar outcomes, even though a study comparing the two procedures reported superior safety outcomes in patients treated using coronal incision [28]. Three studies prescribed penile extender use to overcome the potential risk of scar retraction after ligamentolysis [14,25,28]. For the penile enlargement alone, grafts and flaps were inserted through either peno-pubic or circumcising incisions.

The mean operating times were 66 min when ligamentolysis was performed alone and ranged from 80 to 150 min when it was combined with free dermal fat graft insertion. The mean operating times for enlargement surgeries were 150 and 58 min for the insertion of the superficial circumflex iliac artery and vein flap and porcine dermal acellular matrix graft, respectively. Overall, studies reported statistically significant ($P < 0.05$) mean increases in FPL, SPL and EPL, with ranges of 2.27–3.5 cm, 1.9–3.0 cm and 0.8–1.8 cm, respectively, and mean increases in penile circumference at rest with a range of 1.5–5.1 cm at the end of the follow-up period, without major complications. In addition to two studies reporting increased or unchanged IIEF scores post-surgery [14,15], five studies reported high satisfaction rates ranging from 94.2% to 100% or significantly ($P < 0.05$) increased satisfaction after surgery using validated and unvalidated questionnaires (i.e. brief self-administered questionnaire, MGSIS, SEAR, APPSSI and VAS), without changes in EF and sensibility [16,26–28,30].

Penile Enhancement for Therapeutic Purposes

A total of 39 studies [31–69] evaluated non-invasive (16 papers) [31–44,68,69] and surgical interventions (23 papers) [45–67] aiming to increase penile size in men with concomitant pathologies, including PD (20 studies) [31–39,45–55], ED (12 studies) [40–44,56–62], and other conditions such as buried penis, micropenis, previous pathology repair, corporal fibrosis, and late-onset hypogonadism (seven studies) [63–69].

Non-invasive Interventions in Men with Peyronie's Disease or Erectile Dysfunction of Different Aetiologies

Nine studies [31–39], including two randomized controlled trials (RCTs) [31,33] and one controlled trial [36], evaluated

Table 2 Studies investigating surgical interventions of penile enhancement for aesthetic purposes.

Authors	Study design/ Follow-up/Sample size	Age, mean (range), years	Intervention	FPL		SPL		EPL		Girth mean (SD), cm		Efficacy summary	Safety summary
				Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
Lengthening													
Protogerou et al., 2010 [25]	Obs. Follow-up 12 months (n = 40)	28.3 (22–45)	Ligamentolysis by V-Y plasty + liposuction in selected patients Use of penile extender, Andro-Penis® (Andromedical©, Spain) starting at week 4 post-surgery	9.5 (2.2)	NA	NA	NA	11.8 (1.9)	NA	NA	NA	Significant increase in FPL and EPL compared to baseline	No significant complications. Small haematoma in the area of the incision, n = 1 (no need for additional treatment)
Enlargement													
Xu et al., 2019 [29]	Obs. follow-up 3 months (n = 78)	31.1 (21–66)	Implantation of acellular dermal matrix filler by subcoronal incision.	NA	NA	NA	NA	NA	NA	NA	NA Increase 1.1 (0.5–2.1)		Overall complication rate: 71.8% Prepuce oedema, n = 7 (8.8%) Wound haematoma, n = 8 (10.3%) Delayed healing, n = 12 (15.4%) Skin necrosis, n = 3 (3.9%) Infection, n = 4 (5.1%) Erectile discomfort, n = 547 (60.35)
Shaeer et al., 2014 [15]	Obs. Follow-up 18 months (n = 52)	32 (SD = 7.4)	SCIAV flap by a penopubic incision. Additional ligamentolysis (n = 5)	5.8 (1.3)	8.5 (1.4)	11.9 (2)	11.7 (1.7)	NA	NA	9.3 (1.1) (n = 40) 9.5 (0.6) (n = 8 drop-outs)	14.9 (1.1) (post-surgery) 14.5 (1.1) (18 months) (n = 40) 14.8 (0.9) (post-surgery) (n = 8 drop-outs)	Significant increase in SPL but not in FPL compared to baseline. Significant increase in penile girth post-surgery, maintained at 18 months.	Cases needing revision: Scar revision, n = 11 Bulge at the root of the penis, n = 6 Exaggerated gain in girth, n = 4 Transient postoperative complications: Oedema, n = 52 (100%) Skin ulceration in overweight participants, n = 2 Donor site dehiscence, (12%) Donor site infection (2%)
Alei et al., 2012 [30]	Obs. Follow-up 12 months (n = 69)	28.2 (19–59)	Implantation of porcine dermal acellular graft by a small penopubic incision	NA	NA	NA	NA	9.22 (6.8–12.2)	NA	Flaccid: 8.1 (5.4–10.7) Erect: 10.8 (6.5–15.8)	Flaccid: 11.3 (8.2–13.2) Erect: 13.2 (8.8–14.5)	Significant increase in penile girth in the flaccid and erect state compared to baseline	Temporary: oedema, n = 69 seroma lasting < 1 months, n = 2 moderate graft fibrosis with minor retraction and reduced elasticity of the penis, n = 9

Table 2 (continued)

Authors	Study design/ Follow-up/Sample size	Age, mean (range), years	Intervention	FPL		SPL		EPL		Girth mean (SD), cm		Efficacy summary	Safety summary
				Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
													massive ecchymosis and limited suture dehiscence, $n = 8$ lumps and irregularities $n =$ NA (frequent), subsided within 1 year
Jin et al., 2011 [16]	Obs. Follow-up 9.1 (SD = 5.5) months ($n = 80$)	33 (19–52)	Implantation of a Maxpol T-graft coated with autologous fibroblast by a circumcising incision	NA	NA	NA	NA.	NA	NA	Flaccid: 8.18 (0.8) Erect: 10.26 (1.2)	Flaccid: 11.79 (1.2) (1 months) 12.20 (1.2) (3 months) 12.19 (1.3) (6 months) Erect: 14.29 (1.2) (1 months) 14.75 (1.3) (3 months) 14.28 (1.2) (6 months)	Significant increase in penile girth in the flaccid and erect state at all time points compared to baseline	Prolonged, subcutaneous oedema, $n = 3$ (4.3%) Pinpoint erosion at the suture area, $n = 3$ (4.3%)
Lengthening and enlargement													
Littara et al., 2019 [14]	Obs. Follow-up 12 months ($n = 355$)	38.08 (19–63)	Ligamentolysis by V-Y plasty, $n = 21$ Ligamentolysis by V-Y plasty + autologous fat transfer, $n = 301$ Autologous fat transfer only, $n = 33$ Use of penile extender in patients with severe retraction	8.88 (1.4)	11.6 (0.08*) (2 months) 11.5 (0.09*) (6 months) 11.4 (0.1*) (12 months)	12.4 (1.3)	14.02 (0.07*) (2 months) 13.7 (0.08*) (6 months) 13.5 (0.09*) (12 months)	NA	NA	8.3 (1.2)	11.5 (0.09*) (2 months) 11.36 (0.09*) (6 months) 11.06 (0.1*) (12 months)	Significant increase in FPL, SPL and girth at 2, 6, and 12 months post-treatment compared to baseline.	Temporary decrease in erectile function, $n = 3$ (0.008%) Long-standing haematoma, $n = 4$ (0.011%) Mild loss of sensation, $n = 5$ (0.001%) Delayed wound healing, $n = 4$ (0.0011%) Hypertrophic wound scaring, $n = 3$
Zhang et al., 2016 [26]	Obs. Follow-up 13 (range: 4–24) months ($n = 30$)	23.7 (19–32)	Ligamentolysis by coronal circumference incision and degloving and autologous dermal graft insertion	4.1 (2.4)	6.8 (1.2)	NA	NA	6.6 (0.9)	7.4 (1.1)	At rest: 5.8 (1.0) Erect: 6.4 (0.8)	At rest: 7.3 (0.9) Erect: 7.6 (0.7)	Significant increase in FPL and EPL compared to baseline. Significant increase in girth at rest and in erect state compared to baseline.	Prepuce oedema lasting 1–4 months, $n = 7$ Local skin necrosis not requiring reintervention, $n = 1$
Xu et al., 2016 [27]	Obs. Follow-up 6 months ($n = 23$)	23 (18–33)	Ligamentolysis by V-Y plasty and autologous free dermal fat graft insertion	6.27 (0.53)	8.54 (0.99)	9.42 (1.02)	12.47 (1.26)	NA	NA	8.25 (0.60)	9.92 (0.89)	Significant increase in FPL and SPL compared to baseline. Significant increase in mid-shaft girth at rest compared to baseline.	Short term: Prepuce oedema, $n = 23$ (100%) Long term: Scars of donor sites, $n = 23$ (100%) Unnatural hair growth proximal to the penile stump, $n = 5$ (21.74%) Hypertrophic scar, $n = 2$ (8.7%)

Table 2 (continued)

Authors	Study design/ Follow-up/Sample size	Age, mean (range), years	Intervention	FPL		SPL		EPL		Girth mean (sd), cm		Efficacy summary	Safety summary
				Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
Mertziotis et al., 2013 [28]	Obs. Follow-up 12 months (n = 82)	32 (18–56)	Ligamentolysis: by V-Y plasty, n = 35 (group A) by coronal sulculus incision and degloving, n = 47 (group B) Concomitant autologous free dermal fat graft insertion, n = 79 Penile stretching and use of penile extender starting on the 2nd and 6th week post-surgery, respectively	NA	NA	GroupA: 12.03 (2.2) Group B: 12.31 (2.9)	Group A: 13.95 (3.2) Group B: 14.41 (3.4)	NA	NA	Group A: 6.32 (1) Group B: 6.25 (1.2)	Group A: 8.52 (1.4) Group B: 8.24 (1.3)	Significant increase in SPL and penile girth in both groups compared to baseline No significant differences between groups	Retraction: Group A: n = 4 (11%) Group B: 3 (6%) Hypertrophic scars Group A: n = 18 (51%) Group B: n = 0 Wound dehiscence Group A: n = 5 (1 reoperated) Group B: n = 0

*EPL, erect penile length; FPL, flaccid penile length; NA, not available; Obs., observational; SCIAV, superficial circumflex iliac artery and vein; SPL, stretched penile length. *Median (range).*

PTT (eight studies) [31–38] and vacuum therapy (VT; one study) [39] to increase penile length in 773 men with PD of several grades or stages. Five papers [40–44], including one RCT [42], evaluated VT (three studies) [40–42], PTT (one study) [43], and rehabilitation (one study) [44] before or after penile prosthesis (PP) placement in 253 men with ED (Table 3).

Except for one study [43], PD was an exclusion criterion in the studies focusing on patients with ED, whereas 'no ED' was an inclusion criterion in four of the nine studies in patients with PD [31,32,34,39].

Overall, non-invasive interventions were associated with a few minor complications and reported beneficial effects of traction or vacuum device in increasing penile length [32–34,37,38,40–44]. In patients with stable PD, four studies reported improved penile curvature [31–33,39], and one paper reported efficacy in avoiding subsequent surgery for patients in the acute phase of the disease [36]. Interestingly, five studies found relationships between pretreatment EPC and EPC response, and duration of PTT and SPL gain and EPC response [31,34–36,38], whereas two studies found no relationships [32,34].

Patient satisfaction for the non-invasive intervention, measured as perceived improvement or using non-validated questionnaires, was mostly medium to high, with greater satisfaction regarding EPC correction compared to length improvement.

Surgical Interventions in Men with Peyronie's Disease or Erectile Dysfunction of Different Aetiologies

A total of 18 studies investigated surgical interventions for penile restoration in men with PD (11 studies) [45–55], and preservation of penile length during PP placement in men with ED (seven studies) [56–62] (Table 4).

Of the 11 studies focused on surgical intervention in PD, nine papers reported stable PD as an inclusion criterion [45–49,51–54]. Of the seven studies focused on PP placement for ED, two studies excluded men with PD or corporeal fibrosis [57,62], while four included a high proportion (33–60.1%) of men with concomitant PD [58–61].

Mean surgical times for penile restoration in men with PD by grafting (with or without plaque incision) or PP placement were similar, ranging from 135 to 165 min. In contrast, the mean surgical time required for PP placement in men with ED was <90 min, except for two studies assessing the sliding and multiple-slit techniques for the placement of malleable and inflatable PP, in which mean surgical times were substantially longer (93–140 min), particularly for the placement of the inflatable PP [58,61].

Table 3 Studies investigating non-invasive interventions of penile enhancement for patients with penile disorders.

Authors	Study design/ Follow-up/ Sample size	Age mean (range), years	Intervention	SPL		EPC		Girth		IIEF		Efficacy summary	Safety summary
				Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
Peyronie's disease													
Moncada et al., 2019 [31]	RCT follow-up 12 weeks (n = 93)	PTT group: 57.9 (11.7) NIG: 58.2 (11.6)	PTT group, n = 47: PTT with PeniMaster (PRO) traction device. Device use (prescribed): 3.8 h/day for 12 weeks NIG, n = 46	PTT group: 11.9 (3.0) NIG: 11.2 (3.4)	NA	PTT group: 72.3 (61–105) NIG: 68.7 (58–102)	PTT group: 60.3 (NA) (4 weeks) 47.2 (NA) (8 weeks) 41.1 (NA) 12 weeks NIG: 68.1 (NA) (4 weeks) 67.6 (NA) (8 weeks) 66.3 (NA) (12 weeks)	PTT Group: 11.3 (2.2) NIG: 10.8 (3.1)	PTT Group: 11.9 (2.9)	PTT Group: 23.6 (22–27) NIG: 22.9 (21–28)	PTT group: 26.1 (22–29)	PTT group: Significant reduction in penile curvature. Significant increase in SPL compared to baseline and to NIG. Symptom improvement (PDQ).	Temporary and mild: Local discomfort and glans numbness: (43%) causing withdrawal from the study: glans oedema, n = 2, resolved with local measures and stopping PTT for 24–48 h. Penile shaft pain due to over-stretching beyond the recommended, n = 1
Alom et al., 2019 [32]	Obs. follow-up until 6 weeks after last injection series (n = 113)	Group 1: 56 (53–61)* Group 2: 59 (53–65)* Group 3: 57 (49–63)*	Group 1, n = 52: CCH Group 2, n = 45: CCH and PTT device other than RestoreX® Group 3, n = 16: CCH and RestoreX®. Device use, mean (range): Group 2: 1.5 (0.8–2.2) h/day Group 3: 0.9 (0.6–1.0) h/day	Group 1: 11.5 (10–13)† Group 2: 13 (11–14.5)† Group 3: 12 (10–14)†	NA Change: Group 1: 0 (−1.6–0.6)† Group 2: 0 (−2–1)† Group 3: 1.75 (1–3)†	Group 1: 60 (45–75)† Group 2: 61.5 (45–75)† Group 3: 65 (50–85)†	NA Improvement: Group 1: 16.5 (10–30)† Group 2: 20 (5–32.5)† Group 3: 30 (25–44.4)†	NA	NA	NA	NA	Significantly higher increase in length and curvature improvement in group 3 compared to groups 1 and 2. No significant differences in length and curvature between groups 1 and 2.	Ecchymoses: 100% (all groups) Haematomas: Group 1, 31% Group 2, 50% Group 3, 19% Suspected fracture: Group 1, n = 1 (2%) Group 2: n = 2 (4%) Group 3, n = 0
Ziegelmann et al., 2019 [33]	RCT Follow-up 3 months (n = 110)	Control: 58.1 (SD = 9.7) PTT: 58.5 (87.0)	Controls, n = 28 PTT (RestoreX®) 30 min (n = 82): 1×/day, n = 27 2×/day, n = 28 3×/day, n = 27	Control: 14.8 (1.5) PTT: 14.8 (1.4)	NA Change: Control: 0 (0.7) PTT: 1.5 (1.1)	Control Primary: 44.2 (12.0) Composite 58.3 (25.3) PTT: Primary: 45.4 (13.4) Composite: 59.7 (22.6)	NA Change: Control Primary: −1.1 (7.5) Composite 1.3 (19.0) PTT: Primary: −8.5 (10.1) Composite: −11.7 (15.0)	NA	NA	Erectile function: Control: 19.7 (8.5) PTT: 19.2 (9.7)	NA Change: Erectile function: Control: −1.3 (6.7) PTT: 2.5 (6.3)	Significant improvement in SPL, curvature and erectile function in men undergoing PTT compared to controls. Tendency towards increased symptom improvement in PTT group compared to controls (PDQ)	Mild, spontaneously resolved: Erythema or discoloration, 45.2% Altered penile sensation, 25.8% Cold glans, 3.2% Mild penile pain, 53.2% Bump, 1.6% Swelling, 3.2%
Ziegelmann et al., 2017 [34]	Obs. follow-up: end of treatment (4 series of CCH injections, at least 6 weeks apart) (n = 51)	57.7 (SD = 8.4)	CCH injections with concomitant PTT (Andropenis®, Andromedical America-Asia; New York). PTT + group: (CCH and PTT), n = 35 PTT − group, n = 16 Device use, mean	PTT +: 13.5 (1.9) PTT −: 13.8 (2.2)	PTT +: 13.5 (1.9) PTT −: 13.8 (2.2)	Primary curve: PTT +: 55.7 (19.3) PTT −: 50.8 (19.8) Composite curve: PTT +: 67.4 (25.1) PTT −: 62.1 (24.9)	Primary curve: PTT +: 39.6 (21.7) PTT −: 30 (18.5) Composite curve: PTT +: 46.8 (28.5) PTT −: 38.4 (19.9)	NA	NA	NA	NA	Significant improvement in curvature in both groups No significant differences in mean penile curvature improvement between groups. Trend towards increased SPL in PTT + group	NA

Table 3 (continued)

Authors	Study design/ Follow-up/ Sample size	Age mean (range), years	Intervention	SPL		EPC		Girth		IIEF		Efficacy summary	Safety summary
				Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
			(SD): 1.7 (0.9) h/day and 9.64 (6.3) h/week									compared to PTT- group	
Yafi et al., 2015 [35]	Obs. follow-up: NA (n = 127)	54.4 (SD = 9.5)	Intralesional IFN injection Group 1: with concomitant regular PTT use (Andropenis®) Group 2: without concomitant regular PTT use	Group 1: 13.2 (1.6) Group 2: 13.2 (1.8)	NA Change: Group 1: 2.4 (0.9) mm. Group 2: 1.3 (0.8) mm. Group 1 using the device ≥3 h/day (n = 10): 4.4 (NA) mm.	Group 1: 42.2 (14.6) Group 2: 42.3 (20.8)	NA Change: Group 1: −8.1 (16.0) Group 2: −9.9 (11.8)	Erect state: Group 1: 11.3 (1.2) Group 2: 11.4 (1.4)	NA Change erect state: Group 1: 3.2 (0.6) Group 2: 2.1 (0.7)	Group 1: 16.4 (5.5) Group 2: 16.9 (5.7)	NA	No significant differences in changes in SPL, EPC, and Girth between both groups. Significant differences in changes in SPL between patients using PTT ≥ 3 h/day and patients in Group 2.	NA
Martínez-Salamanca et al., 2014 [36]	CT follow-up 9 months (n = 110)	PTT group: 50.2 (SD = 12) Non-intervention group (NIG): 47.5 (SD = 10)	PTT group, n = 63 (57.3%): PTT with Andropeyronie® (Andromedical, S.L., Madrid, Spain). Device use, mean (range): 4.6 h/day (3.1–9.2) for 6 months Non-intervention group, n = 47 (42.7%)	PTT group: 12.4 (2.1) NIG: 14.5 (3.1)	PTT group: 13.7 (NA) (6 months) 13.9 (NA) (9 months) NIG: 12.1 (NA) (6 months) 11.9 (NA) (9 months)	PTT group: 33 (10–90) NIG: 29 (12–85)	PTT group: 15 (NA) (6 months) 13 (NA) (9 months) NIG: 51 (6 months) 52 (NA) (9 months)	PTT group: 9.5 (1.2) NIG: 8.5 (2.2)	PTT group: 10.3 (NA) (6 months) 10.4 (NA) (9 months) NIG: 8.4 (NA) (6 months) 8.4 (NA) (9 months)	PTT group: 17 (2.5) NIG: 16 (3.5)	PTT group: 24 (NA) (6 months) NIG: 10 (NA) (6 months)	PTT group: significant decrease in penile curvature at 6 months and 9 months Significant increase in SPL and girth (at rest). Significant improvement in erectile function and hardness. No sensory loss. NIG: significant increase in curvature and significant decrease in SPL.	Erythema in the balanopre-pucial sulcus: n = 2, requiring local measures and stopping PTT for 24–48 h. Some degree of discomfort, n = 14 (25.4%).
Rybak et al., 2012 [37]	Obs. follow-up: TAP + PTT: 10.4 (1–30) TAP: 8.3 (1–26) PEG + PTT: 7.1 (1–36) PEG: 6.1 (1–19) (n = 111)	TAP + PTT: 52.6 (34–68) TAP: 53 (32–72) PEG + PTT: 55.4 (49–80) PEG: 56.8 (38–71)	PTT (US PhysioMED, Irvine, CA, USA) following surgical plaque treatment (TAP or partial PEG) TAP + PTT, n = 27 TAP, n = 25 PEG + PTT, n = 36 PEG, n = 23 Device use, mean (range): 2.5 h/day, 4.5 d/week, for 3.8 (1–13) months	Pre-operative: TAP + PTT: 10.8 (7–13) TAP: 11.2 (7.5–16) PEG + PTT: 9.9 (7–12) PEG: 9.9 (7–12)	TAP + PTT: 11.6 (8–14.5) TAP: 10.7 (7.5–15) PEG + PTT: 11.4 (9–14.5) PEG: 10.2 (8–12)	NA	NA	NA	NA	NA	NA	Increase in SPL after PTT in both traction groups compared to preoperative SPL. Significant differences in changes from preoperative to post-PTT SPL between traction and non-traction groups.	Difficulty with application of the device and keeping it on for the desired amount of time: 47%
Abern et al., 2012 [38]	Obs. follow-up 24 weeks (injection protocol) + 1 months (n = 74)	Group I: 57.7 (56.3–59.1) Group II: 58.0 (56.2–59.7)	Group I, n = 39: IVI + Oral L-arginine and pentoxifylline + PTT (US PhysioMED, Irvine, CA, USA), for 24 weeks Device use (mean): 3.3 h/day.	Group I: 11.0 (10.8–11.2)* Group II: 11.0 (10.7–11.3)*	Group I: 11.3 (1.4) Group II: 10.3 (2.2)	Group I: 44.4 (27.5) Group II: 36.6 (18.5)	Group I: 33.4 (25.3) Group II: 21.5 (19.3)	NA	NA	Group I: 21.6 (20.1–23.1)* Group II: 22.5 (20.8–24.3)*		SPL: trend towards an increase with traction (P = 0.06); decrease in the non-traction group. EPC: significantly decreased in both groups. No changes in	Group I: Subcoronal superficial penile skin abrasion attributed to the penile traction device (temporary discontinuation of device use). No permanent

Table 3 (continued)

Authors	Study design/ Follow-up/ Sample size	Age mean (range), years	Intervention	SPL		EPC		Girth		IIEF		Efficacy summary	Safety summary
				Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
			Group II, n = 35: IVI + Oral L-arginine and pentoxifylline									sensibility and erectile function.	adverse sequelae in patients using PTT
Raheem et al., 2010 [39]	Obs. follow-up 12 weeks (n = 41)	51 (24–71)	Use of a vacuum erection device (VED) (Osbon ErecAid®, MediPlus, High Wycombe, UK). Device use (prescribed): 10 min twice daily for 12 weeks	13 (10.4–16)‡	NA Change 0.5 (0.5–1.5)‡ (n = 11)	47.6 (10–95)‡	NA	NA	NA	NA	NA	Significant reduction in the angle of curvature. Significant increase in SPL in 11 patients. Statistically significant improvement in pain (score reduction).	Minor bruising, n = 2 Painful venous engorgement when using the pump, n = 2
Erectile dysfunction													
Antonini et al., 2019 [40]	Obs. follow-up 52 (49–56) weeks (n = 74)	56 (43–66)	Use of a VED (Medis®, VT Devices, Milan, Italy or Osbon ErecAid®, Vacuum Therapy System, Collierville, TN, USA) after AMS™ (Boston Scientific, Marlbor- ough, MA, USA) LGX 700® IPP placement. Device use (prescribed): 5 min twice daily for 12 weeks	13.9 (2.2) EPL:16.2 (1.7) (pharmacological induction)	NA EPL: 13.6 (1.9) (1st postoperatively Activation) 14.9 (1.9) (12 weeks) 16.0 (1.8) (24 weeks) 16.7 (2.0) (48 weeks) (at maximum inflation)	NA	NA	Erect state: 11.0 (0.5) (upon pharmacological induction)	Erect state: 10.3 (0.6) 1st postoperatively activation 10.7 (0.8) (12 weeks) 11.1 (0.8) (24 weeks) 11.3 (0.8) (48 weeks) (at maximum inflation)	9 (range 5–11)	20 (range 18–26) (6 months) 25 (range 20–27) (12 months)	Significant increase in penile length and girth over time. No significant changes in length between baseline ICI-induced and end of follow-up	No complication related to VED use
Zhang et al., 2019 [41]	Obs. follow-up 6 months (n = 78)	Group 1: 32.3 (20–47) Group 2: 33.9 (20–48)	Tadalafil: 10 mg. every other day. Group 1: + VED (Osbon; Timm Medical Technologies Inc.), (n = 36) Device use (prescribed): 10 min twice a day. Group 2: Tadalafil only (n = 42)	NA	NA Changes: Group 1: 0.4 (0.9) Group 2: −0.8 (0.7)	NA	NA	NA	NA	Group 1: 8.3 (3.1) Group 2: 8.5 (3.2)	Group 1: 16.8 (4.2) Group 2: 13.9 (4.2)	Significant differences in changes in SPL between groups after treatment. Significantly higher IIEF in Group 1 vs. Group 2 after treatment.	Pain and discomfort due to improper use of the VED. No further adverse events after experience
Canguven et al., 2017 [42]	RCT follow-up 12 months (n = 51)	VED: 56.1 (10.6) Non-VED: 54.2 (12.3)	VED group: VED prior to PPI (n = 25) Device use: 10–15 min/day during 1–2 months Non-VED group: PPI surgery (n = 26)	VED: 10.7 (1.3) Non-VED: 10.9 (1.3)	VED: 11.5 (1.3) Non-VED: 11 (1.3) Day of surgery	NA	NA	NA	NA	NA	NA	Significant increase in SPL in Group A. Reported by surgeons: smoother corporal dilatation and decreased cavernotome usage in group A	No intra-operative complications associated with the use of VED
Henry et al., 2015 [44]	Obs. Follow-up 12 months (n = 40)	66.2 (NA)	Post-operative rehabilitation after implantation of inflatable	NA	NA Changes: −0.16 (1.2) (postoperatively to 6 months)	NA	NA	NA	NA Changes: 0.69 (0.81) (postoperatively to 6 months)	NA	NA	Significant increase in FPL, SPL, EPL, and girth at 12-months-visit	NA

Table 3 (continued)

Authors	Study design/ Follow-up/ Sample size	Age mean (range), years	Intervention	SPL		EPC		Girth		IIEF		Efficacy summary	Safety summary
				Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
			prosthesis implantation (Coloplast Titan). Daily inflation to discomfort for a short time (6 weeks–6 months) and 1–2 h/day (6–12 months) Aggressive method for cylinder sizing during implantation		0.95 (2) (postoperatively to 12 months)				1.08 (0.8) (postoperatively to 12 months)			compared to postoperative.	
Levine et al., 2011 [43]	Obs. Follow-up: 15 months (n = 10)	57 (33–73)	PTT before PP placement FastSize® penile extender (Aliso Viejo, CA, USA) Device use: 2–4 h/day for 2–4 months	NA	NA Changes (baseline to pre-surgery): 1.5 (range 0.5–3) Changes in EPL (baseline to post-surgery): 0.9 (range 0–1.5).	NA	NA	NA	NA	NA	NA		Difficulty in application of the device for the desired period of time (60%) Occasional pain (40%)

*CCH, collagenase clostridium histolyticum; CT, controlled trial; EPC, erect penile curvature; EPL, erect penile length; FPL, flaccid penile length; ICI, intracavernosal injection; IFN, interferon; IIEF, International Index of Erectile Function; IPP, inflatable penile prosthesis; IVI, intralesional verapamil injections; NA, not available; NIG, non-intervention group; Obs., observational; PDQ, Peyronie's Disease Questionnaire; PEG, plaque excision and grafting; PP, penile prosthesis; PTT, penile traction therapy; RCT, randomized controlled trial; SD, standard deviation; SPL, stretched penile length; TAP, tunica albuginea plication; VED, vacuum erection device; VT, vacuum therapy. *Median (range). †Median (IQR). ‡Range.*

Table 4 Studies investigating surgical interventions of penile enhancement for patients with penile disorders.

Authors	Study design/ Follow-up/Sample size	Age, mean (range), years	Study population characteristics	Intervention	SPL mean (SD), cm		EPC mean (SD), degrees		IIEF		Efficacy summary	Safety summary
					Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
Peyronie's disease												
Morgado et al., 2018 [45]	Obs. Follow-up 49.6 (SD = 2.7) months (n = 32)	57.1 (SD = 6.0)	Stable PD with severe or complex penile deformity Concomitant ED responsive to oral medical therapy, n = 6 (18.8%) No ED (n = 26)	Implantation of the four-layered porcine small intestinal submucosa (SIS) graft (Surgisis® ES) by subcoronal incision and degloving	12.6 (1.7)	13.3 (1.2)	NA	NA	23.3 (2.9)	19.9 (5.9)	Significant increase in stretched penile length at the last follow-up visit Persistent curvature correction	Incisional oedema, n = 2 (6.2%) Haematoma, n = 1 (3.1%) *de novo* ED, n = 14 (53.8%) Long term: Curvature recurrence, n = 8 (25%)
Valente et al., 2017 [46]	Obs. Follow-up 18 (3–36) months (n = 28)	57.8 (SD = 6)	Stable PD disease. Curvature ≥ 60° No ED (2 patients with moderate arterial insufficiency)	Plaque incision and implantation of a porcine small intestinal submucosa graft by circumferential subcoronal incision and penile degloving Additional plaque plication, n = 9 (32.1%) or partial plaque excision, n = 2 (7.2%)	12.5 (1.7)	NA	80.1 (14.9)	NA	NA	NA	Curvature Corrected, n = 23 (82.1%) Residual, n = 5 (17.9%) Length: shorter, n = 4 (14.3%) equal/increased, n = 24 (85.7%) Preservation of erectile function, n = 18 (64.2%)	Infected haematoma (GIIa[‡]), n = 1 Transient penile hypoesthesia (GI[‡]), n = 5 (17.9%) Pain during erection (GI[‡]), 25%
Romero Otero et al., 2017 [47]	Obs. Follow-up 4 (SD = 6) months (n = 43)	50 (IQR 48–52)	Stable PD (>6 months) <55 years Erectile function risk factors, n ≤ 1 Penile curvature >65°	Plaque excision by Egydio's technique and implantation of lyophilized bovine pericardium graft (Peri-Guard®). Use of vacuum device for 10 min, 3 times/day., for 3 months	11.4 (2.7)	11.2 (2.8) (2 weeks) 12.1 (2.9) (3 months)	78 (8) (range 65–95)	Curvature correction: complete n = 33 (80.5%) <20° n = 5 (12.2%) >20° n = 3 (7.2%)	NA	NA	No significant changes in SPL compared to baseline at the two timepoints (post-surgery and VED use). High frequency of curvature correction	No tissue rejection or infection. Glans ischaemia, n = 1 Penile oedema, n = 1 Loss of sensation, n = 2
Rolle et al., 2016 [48]	Obs. Follow-up 37 (9–60) months (n = 28)	63 (45–76)	Stable PD with severe penile shortening and end-stage ED.	Implantation of inflatable (n = 21) or malleable (n = 7) PP using the sliding technique. Prosthesis covered with a porcine small intestinal submucosa (SIS, Surgisis®) and acellular porcine dermal matrix (Pelvicol®) graft (inflatable), and a collagen-fibrin sponge (TachoSil®) (malleable)	8.2 (6–10)*	NA Increase: 3.2 (2.5–4)*	Dorsal 39 (25–70)* (44%) Lateral 30 (20–60)* (44%) Ventral 41 (25–60)* (12%)	NA	27 (11–51)*	45 (30–59)* (3 months) 57 (48–70)* (6 months) 64 (54–74)* (12 months)	Effective penile lengthening in all patients No curvature recurrence. Symptom improvement (PDQ).	No intra-operative complications. Mild and transient haematoma (most patients) Bleeding requiring a blood transfusion (patient on anticoagulation therapy) GII[‡], n = 1 (3.5%) PP infection in diabetic patients, requiring removal of the prosthesis GIII[‡], n = 2 (7%)
Shin et al., 2016 [49]	Obs. Follow-up 39 (NA) months (n = 22)	Group I: 57 (50–63) Group II: 55 (23–75) Group III: 50 (27–63)	Stable plaques and persistent penile curvature Difficulty achieving vaginal penetration. Curvature: Group I: <30°, n = 5 (22.7%) Group II: 30°–60°, n = 11 (50.0%) Group III: >60°, n = 6 (27.3%)	Plaque incision and plication with multiple slit	NA	NA Change: Group I: −0.5 (0.3–0.7)[†] Group II: −0.6 (0.2–1.0)[†] Group III: −0.6 (0.2–1.0)[†]	Group I: 20 Group II: 45 (30–50)[†] Group III: 76 (60–90)[†]	Group I: 2 (0–5)[†] Group II: 7 (0–10)[†] Group III: 14 (10–25)[†]	NA	<10, n = 1 (Group III) 10–21, n = 2 (Group II) >21 n = 5 (Group I), n = 9 (Group II), n = 5 Group III	Penile shortening (82.4%) Significantly decreased degree of curvature in all groups. Long-term maintenance of erectile function (86.4%)	Subcutaneous penile oedema, n = 3 (13.6%)
		56.1 (49–64)			NA			NA	NA	NA		

Table 4 (continued)

Authors	Study design/ Follow-up / Sample size	Age, mean (range), years	Study population characteristics	Intervention	SPL mean (SD), cm		EPC mean (SD), degrees		IIEF		Efficacy summary	Safety summary
					Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
Cosentino et al., 2016 [50]	Obs. Follow-up 19.2 (11–48) months (n = 44)		Severe penile curvature	Plaque incision and implantation of a small intestinal submucosal graft (SIS, Surgisis®). Stretching of the penis for 10 min, 3–4 times/daily for 90 days		NA Decrease: 0.7 (0.5–1.6)	>60° n = 40 (90%) NA n = 4 (10%)				Unclear conclusions about the efficacy	ED, n = 2 (4.5%) Local: Oedema, n = 5 (11.3%) Infection, n = 1 (2.2%) Pain, n = 3 (6%) Ecchymosis and mild discomfort, n = 16 (36.3%)
Egydio et al., 2013 [51]	Obs. Follow-up 18.2 (6–46) months (n = 105)	56.3 (32–75)	Stable, severe PD (disabling) and ED	Penile prosthesis implantation (inflatable or malleable) with concomitant penile restoration by circumferential and longitudinal tunica albuginea incisions and pericardium grafts	NA	NA EPL increase: 3.6 (0.7)	NA 60–90° n = 29 (59.4%) 90–120° n = 13 (40.6%)	NA	NA	NA	Ability to perform satisfactory sexual intercourse n = 104 (99%)	No intra-operative complications Wound infection, n = 1 (1%), resulting in prosthesis removal Retraction with residual curvature ≤ 30°, n = 3 (2.9%)
Zucchi et al., 2013 [52]	Obs. Follow-up 40 (36–84) months (n = 60)	58 (44–76)	Stable PD Normal ED, n = 24 Mild-moderate ED, n = 36 Curvature ≥45°	Plaque incision and implantation of a soft Virilis IR axial prostheses and a saphenous or bovine pericardium collagen matrix graft by subcoronal degloving (n = 54) or double coronal and scrotal incision (n = 6), modified Austoni's technique	NA	NA EPL change: 2 (1.2–2.3)*	NA (45–90)*	NA	15.5 (NA)	19 (NA) (3 months) 21 (NA) (6 months) 23 (NA) (12 months) 23 (NA) (24 months)	Recovery of natural sexual intercourse (80%) Good results using a VAS regarding recovery of original length and girth.	Haematoma of the dartos (re-operated), n = 2 Prosthesis extrusion, n = 1 erosion of the tip of the corpora cavernosa, n = 1 loss of sensitivity, n = = 60 (100%), recovered after 8 months, n = 48 (80%)
Sansalone et al., 2012 [53]	Obs. Follow-up 22 (6–36) months (n = 23)	53 (38–64)	Stable PD (≥6 months) Refractory erectile dysfunction Severe penile shortening.	Concomitant implantation of a Circumferential InteXen® (American Medical Systems) graft and an IPP, using a combined subcoronal and penoscrotal approach	NA EPL: 8.5 (7–10)*	NA EPL change: 2.8 (2.2–4.5)*	70 (45–100)*	NA	9 (4–15)*	NA	Increased penile length Intra-operative correction of curvature (100%) Recovered ability to engage in sexual intercourse (100%).	No intra-operative complications Postoperative: minor wound dehiscence, n = 3 (13.8%) diminished glans sensitivity, n = 4 (20%) residual curvature < 15°, n = 3 (13%)
Sansalone et al., 2011 [54]	Obs. Follow-up 20 (12–24) months (n = 157)	55 (29–70)	Stable PD with IIEF-5 scores ≥15	Plaque incision and implantation of a bovine pericardium collagen matrix graft (Veritas® Collagen Matrix; Synovis Life Technologies, Inc., St Paul, MN, USA) through circumferential subcoronal incision.	NA	NA Increase: 2.5 (1.5–3.5)†	NA	NA	16 (15–21)†	18.5 (17–23)† (3 months) 20.5 (19–24)† (12 months) 22.5 (20–25)† (24 months)	Intra-operative penile curvature correction, n = 157 (100%) Recovered ability to engage in penetrative sexual intercourse, n = 157 (100%),	Mild glans hypoesthesia n = 5 (3%) Residual curvature < 15°, n = 19 (12%) New-onset ED (need of PDE-5 inhibitors to achieve adequate rigidity), 29%
Simonato et al., 2010 [55]	Obs. Follow-up: 95 (81–108) months (n = 26)	56.1 (40–69)	PD No ED	Plaque incision and implantation of penile dermal flap	11.6 (NA)	11 (NA)	30–45°, n = 15 46–90°, n = 11	Residual curvature (long term): No, n = 14 (63.6%) Yes, n = 8 (36.4%)	12.2 (n = 26) 11.95 (n = 22)	12.4 (n = 22)	No significant change in SPL High dissatisfaction Technique discontinued	Inclusion cyst at the surgical site, n = 9 (40.9%). Two inclusion cysts, n = 1
Erectile dysfunction												
Wallen et al., 2019 [56]		60.3 (7.7)	ED	Implantation of the AMS 700 LGX IPP,		11.1 (2.4) 11.2 (2.6)	NA	NA	NA	Erectile function: 27.4 (6.2) (6 months)	Significant decrease in SPL,	No surgical complications

Table 4 (continued)

Authors	Study design/ Follow-up/Sample size	Age, mean (range), years	Study population characteristics	Intervention	SPL mean (SD), cm		EPC mean (SD), degrees		IIEF		Efficacy summary	Safety summary
					Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
	Obs. Follow-up 12 months (n = 26)			through penoscrotal incision. The IPP left deflated 4–8 weeks. Daily inflation until it became slightly uncomfortable for 30–90 min starting at 4 months	12.5 (2.2) FPL: 9.8 (2.2)	FPL: 10.1 (2.3) 10.0 (2.5)				26.1 (8.1) (12 months) Overall: 8.1 (2.3) (6 months) 8.4 (2.3) (12 months)	circumference and width. No changes in FPL. No ED at 18 months, n = 18 (69.2%)	
Shaeer et al. 2019 [57]	Obs. Follow-up NA (n = 126)	DP + PPI: 57.9 (SD = 6.9) Controls: 55.8 (SD = 8.2)	Refractory ED	Dorsal phalloplasty with penile prosthesis implantation (DP + PPI), n = 66 PPI (controls): n = 60 Penoscrotal incision. Penile prosthesis: semirigid penile prosthesis or IPP)	Visible length (from pubic skin surface): DP + PPI: 9.8 (3) Controls: 12.1 (1.6) True length (from pubic bone): DP + PPI: 12.9 (2.5) Controls: 14.5 (1.9)	DP + PPI: 13 (2.5) Controls: 12.1 (1.5) (At final follow up)	NA	NA	NA	NA	DP + PPI: significant increase in visible length, maintained at final follow up.	No infection, extrusion or persistent pain. PPI + DP group: stitch sinus, requiring removal of the tacking suture n = 1
Egydio et al., 2018 [58]	Obs. Follow-up 15.2 (6–36) months (n = 138)	55 (40–72)	Patients with penile deformities affecting anatomy and severe ED. Main causes of ED and shortening: PD, n = 83 (60.1%) Severe ED, n = 34 (24.6%) Radical prostatectomy, n = 14 (10.1%)	Multiple-slit technique (MUST) with concomitant malleable or IPP insertion	NA FPL: 9.8 (7.6–14.3)*	NA FPL increase: 3.1 (2–5)*	55 (0–90) range (patients with PD, n = 83)	NA	22 (11–39)*	61 (NA) (6 months)	Correction of all cases with penile curvature, n = 83 (100%)	Glans necrosis, n = 1 (0.7%) Mild and temporary: Postoperative haematomas at the base of the penile shaft, n = 26 (18.8%) Superficial haematoma on the pubic area, most cases Partial glans numbness, n = 4 (2.9%) Anorgasmia (lasting 4 months), n = 7 (5.1%)
Weinberg et al., 2016 [59]	Obs. Follow-up NA (n = 200)	69 (51–84)	Failed medical therapy for ED. ED aetiology: Diabetes, n = 148 (74%) radical prostatectomy, n = 34 (17%) Stable PD, n = 92 (46%) previously placed IPP malfunction, n = 16	Implantation of a three-piece IPP (Titan Touch or Titan OTR, Coloplast), through a single sub-coronal incision and a modified no-touch technique (scIPP). In patients with PD, additional: plaque plication (24%) relaxing incisions (22%)	12.5 (9–16.5)*	13.1 (9.1–17.2)* 12 weeks at maximum inflation (no lost length at 6 months, n = 116, 58%)	NA	NA	NA	NA	NA	Infection requiring device removal, n = 3 (1.5%) Impending distal erosion of the left cylinder, n = 1 (solved by rerouting of the cylinder)
Negro et al., 2016 [60]	Obs. Follow-up 19 (6–38) (n = 45)	61 (NA)	ED of multiple aetiologies: Mild PD ≤ 30°, n = 15 (33%) Pelvic surgery, n = 18 (40%) Vascular impotence, n = 12 (27%)	Implantation of the AMS 700 LGX IPP, through penoscrotal incision. Prosthesis deflated until 2 weeks post-surgery, activation 1520 min daily thereafter for at least 8 mo	13.1 (1.2) EPL: P50 13.1 (1.2) P100 13.9 (1.3)	13.7 (1.1) (6 months) 14.2 (1.2) (12 months) EPL: P50: 13.1 (1.2) (6 months) 3.1 (1.2) (12 months) P100: 14.3 (1.3) (6 months) 14.4 (1.3) (12 months)	NA	NA	NA	Q6–8: 10.5 (2.7) (6 months) 10.7 (2.1) (12 months) Q10: 4.0 (1) (6 months) 4.2 (1.1) (12 months) Q11–12: 7.6 (1.3) (6 months) 8.6 (1.1) (12 months) Q13–14:	Significant increase in SPL and P100 length at 6 and 12 months compared to baseline. No changes in P50. Significant increase in mean scores of Q11–14 of IIEF between 6 and 12 months	No perioperative complications. Prosthesis infection at 3 months requiring removal, n = 1 *De novo* intra-operative curvature of 30° in PD patients without

Table 4 (continued)

Authors	Study design/ Follow-up/Sample size	Age, mean (range), years	Study population characteristics	Intervention	SPL mean (SD), cm		EPC mean (SD), degrees		IIEF		Efficacy summary	Safety summary
					Baseline	Post-treatment	Baseline	Post-treatment	Baseline	Post-treatment		
										7.3 (1.2) (6 months) 8.3 (1.5) (12 months)		preoperative curvature, $n = 3$ (requiring modelling)
Egydio et al., 2015 [61]	Obs. Follow-up 9.7 (6–18) months ($n = 143$)	20 (40–72)	Severe therapy-resistant ED associated with penile shortening with or without penile curvature. Multiple aetiologies of ED: PD, $n = 77$ (53.8%) Severe ED, $n = 30$ (20.9%).	Modified sliding technique for penile length and girth restoration and concomitant malleable PP (Coloplast Genesis or Promedon Tube) ($n = 133$) or IPP (Coloplast OTR or AMS 700 CX) ($n = 10$) implantation.	NA	NA Increase: 3.1 (2 7	45° (0 –100) (patients with PD)	NA	24 (including both the erectile function and satisfaction domains)	60 (6 months)	Preservation of sensitivity, ability to participate in sexual intercourse, orgasmic and ejaculation ability in all patients. Correction of curvature in all patients with PD.	Transient and spontaneously resolved: Haematomas at the base of the penis, $n = 35$ (24.5%) Superficial haematoma on the pubic area, (most patients) Partial glans numbness, $n = 7$ (4.9%)
Moncada et al., 2010 [62]	RCT Follow-up 6 months ($n = 100$)	Group 1: 59.2 (SD = 6.2) Group 2: 60.3 (SD = 5.4)	ED unresponsive to treatments	IPP implantation 700CX™ ($n = 70$) or 700CX InhibiZone™ ($n = 30$). Group 1: without penile dilatation ($n = 50$) Group 2: with penile dilatation ($n = 50$)	Group 1: 8.9 (7–9.5)* Group 2: 9.2 (6–9.9)*	Group 1: 10.2 (9–11.2)* (postoperative) 10.1 (9.2–11.5)* (3 months) 10.0 (9.5–12.5)* (6 months) Group 2: 8.5 (7–9.2)* (postoperative) 8.3 (6.8–9.1)* (3 months) 8.0 (6.2–8.9)* (6 months) (Inactivated prosthesis)	NA	NA	NA	Group 1: 12 (10–14) Group 2: 7 (6–8) (questions 1–3)	Significant differences between groups at all time points Higher postoperative IIEF scores in group 1 compared to group 2.	Intra-operative Group 1: crural perforation, $n = 1$ urethral perforation, $n = 1$ Group 2: crural perforation, $n = 1$ Crossovers, $n = 2$ Postoperative Group 1: infection, $n = 1$ Haematoma, $n = 1$ Group 2: infection, $n = 1$

*DP, dorsal phalloplasty; ED, erectile dysfunction; EPC, erect penile curvature; EPL, erect penile length; FPL, flaccid penile length; IIEF, International Index of Erectile Function; IPP, inflatable penile prosthesis; IQR, interquartile range; NA, not available; Obs., observational; PDE-5, phosphodiesterase-5; PD, Peyronie's Disease; PDQ, Peyronie's Disease Questionnaire; PP, penile prosthesis; PPI, penile prosthesis implantation; RCT, randomized controlled trial; scIPP, sub-coronal inflatable penile prosthesis; SD, standard deviation; SPL, stretched penile length; VAS, visual analogue scale; VED, vacuum erection device. *Range. †Median (range). ‡Clavien-Dindo classification.*

Unlike the studies assessing non-invasive interventions, the studies evaluating surgical procedures reported efficacy results mainly using qualitative variables; indeed, only eight studies [47,49,55,56,58,60–62] reported quantitative changes in EPC and IIEF in patients undergoing surgery for PD and ED, respectively.

Overall, surgical interventions for penile restoration and curvature correction in men with PD were effective, allowing patients to engage in penetrative intercourse, and the satisfaction rates, assessed using a variety of non-validated instruments, were mostly high (82.2–97%). Similarly, interventions to preserve penile length in men undergoing PP placement were effective, and the satisfaction rates, assessed using different instruments, were high, except for one study reporting decreased SPL but high satisfaction rates [56].

Interventions in Men with Other Pathologies

Regarding surgical interventions, the combination of ligamentolysis and graft implantation was used for penile enhancement after hypospadias repair (n = 15) and in patients with a buried penis (combined with liposuction; n = 15) and micropenis (n = 19), leading to satisfactory results with minor complications [63–65]. In 23 men with complications after epispadias repair, penile reconstruction using tunica albuginea incision and grafting followed by urethral reconstruction yielded satisfactory results, with a cosmetically acceptable penile appearance and good EF [66]. Another study used liposuction in 22 patients with a buried penis, reporting significant ($P < 0.05$), albeit modest, mean increases in penile length (1.1 cm; SD = 0.35) [67].

Non-invasive interventions were intramuscular injections of testosterone and VT in 88 men with ED due to late-onset hypogonadism and 13 men with corporal fibrosis of different aetiologies requiring PP, respectively. Despite the lack of significant changes ($P > 0.05$) in the penile length in both studies, injections with testosterone resulted in significantly ($P < 0.05$) increased mean IIEF scores, and VT during at least 3 months before PP placement resulted in maintained or increased FPL in all patients [68,69].

Discussion

Most studies conducted within the last decade to evaluate procedures of penile enhancement in healthy men and men with concomitant penile disorders report effective increases of penile dimensions or corrections of penile deformities with few associated major complications. However, the bulk of scientific evidence is mainly based on studies with poor internal validity (e.g. observational designs, non-standardized methodologies, heterogeneous populations) [2,5–8].

The papers included in the present review analysed changes in penile dimensions inconsistently, underscoring the lack of a consensus to assess and report efficacy outcomes. Similarly, previous reviews had acknowledged the lack of valid methods for evaluating outcomes, particularly in interventions with aesthetic indication [5,6]. Unlike the previous reviews [5–7,10], this is the first paper that comprehensively analyses both interventions performed for purely aesthetic purposes and procedures performed for therapeutic reasons in patients with concomitant penile disorders. Furthermore, it does not focus on a specific group of interventions (surgical or non-invasive) or a specific condition or disease (e.g. PD). Finally, it analyses interventions aimed at both improving the length and circumference of the penis.

Studies assessing surgical interventions in men with concomitant pathologies tended to report efficacy outcomes using qualitative variables and often lacked comparisons between pre- and post-intervention measures. In this respect, despite the availability of the Peyronie's Disease Questionnaire (PDQ) [77] to assess effects in PD symptoms, only three of the 20 studies in PD patients used it to assess efficacy outcomes [31,33,48]. This fact could partly be explained because the PDQ became available in 2013–2014. Likewise, the IIEF, a validated instrument to assess EF was administered after the intervention in 17 (53.1%) [31,33,36,38,40,41,45,48,49,52,54–56,58,60–62] of the 32 studies in patients with PD or ED, while other studies used self-developed or not validated questionnaires, therefore changes in EF after the intervention remained underreported in 15 (46.9%) studies [32,34,35,37,39,42–44,46,47,50,51,53,57,59]. However, with the exception of three interventions using PTT that showed limited efficacy (<2 and 4.4 mm increases in length in normal men and patients with PD, respectively) [17,18,35], most interventions included in this study effectively resulted in increased penile length and/or corrected penile curvature.

Similar to efficacy outcomes, safety outcomes and patient satisfaction were inconsistently reported. Most interventions were associated with minor temporary complications, and only one intervention reported a major complication, glans necrosis [57]. Even though most interventions were safe, four interventions required PP explant due to infection in a total of seven patients, one study reported haematoma requiring re-operation, three studies reported *de novo* ED, and two aesthetic interventions needed revision [15,22,45,48,50–52,54,59,60]. However, the poor reporting of complications, with only two studies using objective classifications [46,67] (i.e. the Clavien–Dindo classification of surgical complications [78]), precluded a systematic safety evaluation.

A variety of inconsistent instruments were used to assess patient satisfaction, including available questionnaires and self-developed questionnaires, such as APPSSI, SEAR, MGSIS,

MSQ and VAS, whereas only eight studies used the validated Erectile Dysfunction Inventory of Treatment Satisfaction (EDITS) [79] to evaluate treatments for ED [45,46,48,51,53,58,60,62].

Altogether, the lack of standardization of the efficacy and safety measures impacts the quality of the clinical evidence. In the context of aesthetic enhancement of penile dimensions, this limitation is particularly relevant when assessing the risk/benefit of the available interventions and for making guided decisions.

Even though the interventions reported in this review were based on only few main methodologies (traction therapy, injection of fillers, ligamentolysis, optimization of PP placement, grafting, and plaque incision), none of the interventions described was reproduced identically because they were combined with additional procedures or used different devices and materials. For example, dissection of the suspensory ligament for aesthetic penile lengthening was performed with concomitant grafting of different materials for enlargement, with and without additional PTT regimens [14,25–28], and graft implantation in patients with PD was combined with plaque incision and/or PP placement [45–55]. Likewise, non-invasive interventions used a variety of devices and regimens for PTT or VT and different filling substances [13,17–24,31–39,40–44]. In other words, the literary landscape of these interventions, particularly those aimed at increasing penile size for aesthetic purposes, shows high heterogeneity regarding techniques, materials and devices. Thus, despite sharing common principles, to our knowledge, the complete interventions were unique and lacked external validation.

Despite the variety of interventions, results from this review show that PTT was successfully used in aesthetic and therapeutic indications, without associated complications [17,18,31–38]. Interventions using PTT with aesthetic purposes required demanding treatment regimens and showed modest results, probably due to poor treatment adherence [17,18]. In this regard, a subset of studies found associations between duration of PTT and efficacy outcomes (i.e. SPL gain and EPC response), and recent studies in men with PD using advanced extenders (i.e., RestoreX® – PathRight Medical Inc., Minnesota, MN, USA) showed efficacy despite their use during shorter periods [31–33,35,38]. Altogether, these observations warrant further studies designed to validate the efficacy of PTT in different settings and to investigate the patient and treatment factors influencing efficacy outcomes.

Recently, an implantable silicone device has been cleared by the US Food and Drug Administation for penile cosmetic enhancement: Penuma® (International Medical Devices, Beverly Hills, CA, USA). The device is available in three different length sizes and it is inserted overlying the tunica albuginea of the penis, preserving the suspensory ligament. In a study in 400 patients [80], an increase of the midshaft circumference from an average of 8.5 ± 1.2 cm to 13.4 ± 1.9 cm (56.7% increase; $P < 0.001$) was observed. A two-category improvement in self-confidence and self-esteem was noted in 83% of patients 6–8 weeks postoperatively in APPSSI scoring. These promising results have to be validated in larger and multicentre studies to reach definite conclusions.

The results of this systematic review should be interpreted in the context of its limitations, one of which includes the poor data quality of papers included and the great heterogeneity of the interventions evaluated. Furthermore, the outcomes and patient satisfaction in the studies were often assessed and reported without standardized criteria. Lastly, most studies reported only short follow-up periods, focusing on postsurgical and short-term outcomes, whereas data after extended follow-up was often omitted. In addition, given the acknowledged level of underreporting of interventions with aesthetic purposes, probably due to clinical and research barriers, we cannot exclude a bias towards publishing mainly positive data.

Considerations for Future Research

Despite the discussed limitations and inconsistencies, this review summarizes the most recent advances in the literature on the topic and underscores the encouraging results of non-invasive procedures as a safer alternative to surgery or as adjuvant therapy. We hope that this article can be a starting point for the development of new large RCTs regarding surgical and non-invasive interventions of penile enhancement for aesthetic and therapeutic purposes, but above all that it can incentivize researchers to use validated and standardized measurement tools for future studies.

In conclusion, a wide variety of treatments aiming to increase penile dimensions for aesthetic purposes or restore penile size in patients with concomitant pathologies is currently available. However, the lack of standardized criteria to evaluate and report efficacy, safety and patient satisfaction has led to a prevalence of poor-quality studies that blur the picture of scientific evidence and preclude drawing strong conclusions regarding the actual efficacy and safety of these interventions. In light of this, a consensus on validated methods to assess the efficacy and safety of penile lengthening and enlargement treatments would be needed to evaluate systematically the outcomes of these procedures and establish evidence-based recommendations.

Conflicts of Interest

All co-authors have nothing to disclose.

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Abbreviations: APPSSI, Augmentation Phalloplasty Patient Selection and Satisfaction Inventory; ED, erectile dysfunction; EF, erectile function; EPC, erect penile curvature; EPL, erect penile length; FPL, flaccid penile length; IIEF, International Index of Erectile Function; MGSIS, Male Genital Self-Image Scale; MSQ, Male Sexual Quotient; PD, Peyronie's disease; PDQ, Peyronie's Disease Questionnaire; PICO, Population, Intervention, Comparator, Outcome; PMMA, polymethylmethacrylate; PP, penile prosthesis; PTT, penile traction therapy; RCT, randomized controlled trial; SPL, stretched penile length; SEAR, Self-Esteem and Relationship; VAS, visual analogue scale; VT, vacuum therapy.

