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Penile Length and Its Preservation in Men After Radical Prostatectomy

Lillian Y. Lai[1] · Alan W. Shindel[1]

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Abstract

Purpose of Review Penile changes (most prominently shortening) after radical prostatectomy (RP) can negatively influence body image and quality of life. Here, we review the relevance of penile length to sexual satisfaction, the etiology of penile shortening after RP, and interventions that may preserve penile length.

Recent Findings Most studies measure flaccid stretched penile length from the penopubic skin junction to the glans tip; however, the technique reportedly underestimates erect length by 23%. There is evidence that oral pharmacotherapy and mechanical devices may provide some benefit for length preservation, but the evidence basis remains marginal. Surgical augmentation in the setting of penile shortening may be efficacious but carries risks including potential for failure and/or worsening deformity.

Summary Penile length loss (perceived or objective) can have a major impact on quality of life after radical prostatectomy. Additional research is required to understand optimal means to help men preserve penile length after RP.

Keywords Penile shortening · Radical prostatectomy · Penile length · Erectile function · Penis · Patient satisfaction

Introduction

Prostate cancer (PC) is the most commonly diagnosed cancer in men and the second leading cause of cancer death in the USA [1]. A variety of treatment options exist for PC, including radical prostatectomy (RP) [2]. Erectile dysfunction (ED) and stress urinary incontinence are well-known adverse effects of RP that dominate the peer-reviewed literature on PC survivorship. Loss of penile length and/or new onset penile deformity has also been associated to RP [3–6, 7••, 8, 9, 10•, 11], but is not mentioned in the current American Urological Association nor European Association of Urology guidelines on RP as management of PC [12, 13].

A study of 948 men with recurrent prostate cancer who were surveyed at a median of 5.53 years after RP or radiotherapy (RT) with or without androgen deprivation therapy (ADT) found that RP ($p = 0.04$) and RT with ADT ($p = 0.16$) were associated with more complaints of reduced penile size than RT alone [14••]. After adjusting for age, treatment type, and baseline comorbidity, reduced penile size was associated with more treatment regret (OR 2.27, 95% CI 1.37–8.26; $p = 0.0079$), increased risk of interference with close emotional relationships (OR 2.36, 95% CI 1.02–5.47; $p = 0.044$), and a near-statistically significant interference with overall enjoyment of life (OR 2.35, 95% CI 0.997–5.546; $p = 0.0507$).

Penis size is viewed as a measure of masculinity and sexual prowess in many cultures [15]. A study of 52,031 heterosexual men and women reported that only 55% of men were satisfied with their penis size [16]. Satisfaction with penile size did not vary across age groups from 18 to 65, suggesting that dissatisfaction is not a phenomenon of any particular age bracket. In contrast, 85% of women in this study reported satisfaction with their partner's penis size [16]. In a separate survey, 77% of 170 sexually active women rated penile length as unimportant or totally unimportant; girth was more frequently considered to be important than length was (32 vs 21%, respectively) [17].

Interestingly, in studies of women asked to evaluate penis sizes of computer-generated models (independent of an actual

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✉ Alan W. Shindel
alan.shindel@ucsf.edu

[1] Department of Urology, University of California, San Francisco, 400 Parnassus Ave, Ste a610, San Francisco, CA 94143-0738, USA

partner), there is an indication of esthetic preference for a larger phallus [18, 19]. A study of 105 women found that male figures were deemed more attractive as their flaccid penile size increased; however, the per-unit marginal increase in attractiveness declined as size increased [18]. In another study (n = 60), women selected three-dimensional erect penis models of slightly above average as their ideal size for both one-time and long-term partners, although only penile circumference remained significant after statistical adjustment [19]. Although individual variation exists, it appears that women are satisfied with partner penis size in general, despite having an appreciation—perhaps esthetically—for larger phalluses. Regardless of women's preferences, men tend to overestimate the erect length that women find desirable in a partner (18.01 vs 15.47 cm, respectively; n = 67 men and 43 women) [20].

The value a patient attaches to altered body features affects the perception of change more so than the actual severity and type of alteration [21, 22]. Hence, the potential for loss of penile length should be discussed before RP in order to set expectations and hopefully reduce risk of treatment regret. In this manuscript, we provide a review of existing data on changes in penile length following RP and mitigation strategies intended to preserve penile length.

Measuring Penile Length

Flaccid stretched penile length (SPL) is a widely used measurement of penile length to approximate erect penile length [23, 24]. Most commonly, flaccid SPL is defined as the linear distance of the dorsal side of the penis extending from pubopenile skin junction to the tip of the glans in the flaccid state (Fig. 1) [3, 4, 7••, 24–26]. Arousal, recent ejaculation, temperature, or inclusion/exclusion of the suprapubic fat pad may alter this measurement [24, 27•, 28]. Axial traction should be applied to the penis until the participant feels a mild discomfort [24]. Forces exerted by urologists in clinical settings are typically significantly less than the minimal tension force required to reach potential erection length predicted by engineering analysis ($p < 0.01$) [29]. A multicenter, multi-observer (n = 7 andrologists) study of penile length measurement in 201 adult men demonstrated that assessing the penis in the stretched, flaccid penopubic skin junction to the glans tip fashion underestimated the erect measurement by 23.39%, with BMI as a major factor in limiting the accuracy [30].

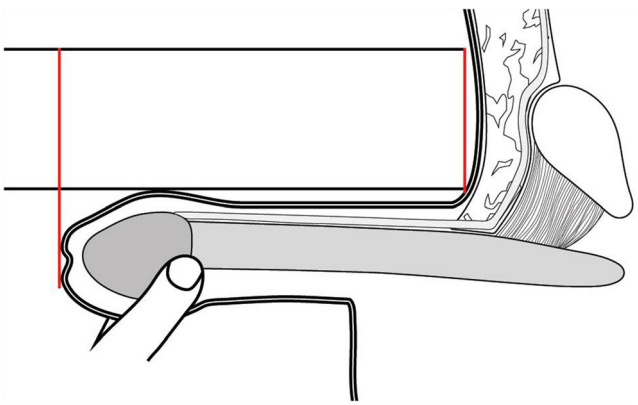

Fig. 1 Measurement of stretched penile length. The red vertical lines represent the recommended proximal and distal extent of measured penile length

Penile Length Changes After Radical Prostatectomy

Fraiman et al. were among the first to report penile shortening after RP [31]. By categorically analyzing penile measurements by time since surgery, the authors inferred that the RP cohort had an 8 and 9% decrease in flaccid and erect length, respectively. However, there was no preoperative measurement and all patients had measurement at a single point in time; true decrease in size cannot be determined from these data. In the first prospective study of penile length loss after RP, 22 of 31 patients (71%) had a decrease in SPL between 0.5 and 4.0 cm at 3 months after surgery compared to preoperative measurements; 15 patients (48%) had a decrease of at least 1.0 cm [3]. Another prospective study of 63 RP patients using the same measurement technique reported a mean decrease in SPL by 1.1 cm ($p < 0.001$); 43 of 63 patients (68%) had a decrease in SPL of 0.5 to 5.0 cm at 3 months after nerve-sparing RP with 19% having a $\geq$ 15% decrease [4].

The time course of penile length changes after RP remains unclear. A study of 126 RP patients determined that mean penile length loss progressed over the first year to an overall mean loss of 2 cm at 12 months follow-up [5]. A longer term (up to 60 months) study of 105 RP patients found a mean decrease of approximately 1 cm from baseline ($p < 0.001$) at 3, 6, 12, and 24 months [7••]. Mean difference from baseline in penile length was not statistically significant at 48 and 60 months ($p = 0.080$ and $p = 0.065$, respectively), but this may have been driven by a high dropout rate. Despite these results, other studies have reported a return to baseline length by 9 to 12 months after RP [6, 10•].

Patient perception is more clearly relevant to overall satisfaction than physician measurement. In a cross-sectional survey, 1288 RP patients (median 24 months postoperative; mean age 64.8) and 350 controls (mean age 63.0) answered the question "Is your penis shorter compared to when you were 30 years old?" [8]. RP patients were more likely to report shortening (n = 663, 55%), as compared to controls (n = 85, 26%) [8]. After adjusting for age, ED, and cardiovascular diseases including angina and heart failure, the authors found a relative risk of 1.7 (95% CI 1.4–2.1) for self-perceived penile shortening in RP patients compared to controls. Another

survey of 316 RP patients (median time of 17 months postoperative) found that 47% of patients endorsed a subjective penile length loss in excess of 1 cm [9]. Data on penile length changes after RP are summarized in Table 1.

Table 1 Studies on penile length changes after radical prostatectomy, arranged by year of publication

First author (year) [ref]	Sample size	Mean age (years)	Measurement/response timing	Nerve-sparing status	Penile length changes
Fraiman 1999 [31]	100	60.6	No preoperative measurements. Mean 9.4 months after surgery	90% BNS	Mean decrease of 8% in flaccid length and 9% in erect length. No longitudinal assessments. Information on penile rehabilitation strategy not reported
Munding 2001 [3]	31	Not reported	Before surgery, 3 months follow-up	Not reported	71% had decrease in SPL (range 0.5 to 4.0 cm). 48% had decrease in SPL ≥ 1 cm. Information on penile rehabilitation strategy not reported
Savoie 2003 [4]	63	59.1	Before surgery, 3 months follow-up	75% BNS	68% had significant decrease in SPL (range 0.5 to 5.0 cm). Information on penile rehabilitation strategy not reported
Gontero 2007 [5]	126	65.4	Before surgery, catheter removal (7–10 days post-RP); 3, 6, and 12 months follow-up	39.68% UNS or BNS	Mean decrease of 0.84 cm (95% CI 0.62–1.06; $p < 0.0001$) at catheter removal; subsequent lesser but significant decrease at all intervals for a total mean decrease of 2.03 cm at 12 months follow-up. Information on penile rehabilitation strategy not reported
Briganti 2007 [32]	33	56.5	Before surgery, 6 months follow-up	100% BNS	No statistically significant change in flaccid/erect length or circumference, IIEF, or Doppler evaluation at 6 months after surgery. Information on penile rehabilitation strategy not reported
Engel 2011 [6]	127	56.5	Before surgery and 1, 3, 6, 9, 10, and 11 months follow-up	100% BNS	Mean decrease in SPL of 0.64 ($p = 0.0001$), 0.32 ($p = 0.009$), and 0.26 cm ($p = 0.02$) at 1, 3, and 6 months. No significant difference at 9, 10, and 11 months. Mean follow-up of 9.5 months. Patients were on either intraurethral alprostadil or oral sildenafil.
Vasconcelos 2012 [7••]	105	65	Before surgery and 3, 6, 12, 24, 36, 48, and 60 months follow-up	Not reported	Mean decrease of 1 cm at 3 months ($p < 0.001$) which persisted until 24 months. No significant difference at 48 and 60 months but few patients with data at these time points (33 and 14, respectively). Patients on penile rehabilitation were excluded.
Carlsson 2012 [8]	1208	64.8	Mean 24.2 months after surgery	Only available for subset of patients	55% of men who underwent radical prostatectomy responded "yes" to "Is your penis shorter compared to when you were 30 years old?" Relative risk of 1.7 of self-perceived penile shortening compared with age- and residency-matched control (95% CI 1.4–2.1). Information on penile rehabilitation strategy not reported
Frey 2014 [9]	316	64	Median 17 months after surgery	44% UNS 32% BNS	47% reported a subjective loss of penile loss of > 1 cm. Information on penile rehabilitation strategy not reported
Kadono 2017 [10•]	102	64.4	Before surgery, 10 days, and 1, 3, 6, 9, 12, 18, and 24 months follow-up	54.9% UNS 23.5% BNS	Mean decrease of 1.99 cm at 10 days after surgery ($p < 0.05$). No significant difference by 12 months. 25.5% used PDE5I after RP. PDE5I use was not predictive of length change.

UNS, unilateral nerve-sparing; *BNS*, bilateral nerve-sparing; *SPL*, stretched penile length; *IIEF*, International Index of Erectile Function

Pathophysiology of Penile Shortening After RP

Multiple theories have been proposed to explain the decrease in penile length after RP. Retraction of penile structures with decreased extensibility due to excision of the prostatic urethra is a simple hypothesis that may explain some penile length loss [10•]. Sympathetic hyperactivity, smooth muscle apoptosis, and cavernous hypoxia-induced fibrosis have been proposed as additional etiological factors [28, 31, 33]. Hormonal ablation, while not currently standard of care as an adjunct to RP [2], is used as adjunct or second-line therapy in some RP patients and may also contribute to penile length loss [34].

Urethral Shortening/Retraction

A study of pelvic MRI performed preoperatively, 10 days postoperatively, and 12 months postoperatively demonstrated proximal retraction of the membranous urethra and bulb of the penis immediately after surgery with recovery to the preoperative position at 12 months [10•]. The anatomical change noted on imaging correlated with shortest penile length at 10 days but no significant difference from baseline at 12 months after surgery. The volume of removed prostate (a proxy for urethral length resected) was a predictor of length reduction at 10 days postoperative ($p = 0.036$), but the association did not maintain strict significance on multivariate analysis ($p = 0.061$). Several other studies have failed to show correlation between penile length loss and prostate size/weight [4–6], arguing against urethral length loss as a major factor in penile shortening.

Sympathetic Hyperactivity

The pelvic plexus and cavernous nerves are susceptible to injury during RP due to their proximity to the prostate. Following injury, cavernosal nerves undergo Wallerian degeneration and a regenerative response is initiated in the neuronal cell body [35]. Sympathetic fibers regenerate more quickly than the parasympathetic fibers, leading to increased sympathetic tone [36]. This sympathetic hyperinnervation may contribute to a penile hypertonic state that predisposes to penile contraction [33].

Smooth Muscle Apoptosis

Loss of penile smooth muscle is noted as early as 2 months after RP [37]. This process is thought to be driven by apoptosis in subtunical smooth muscle, a phenomenon observed after bilateral cavernous neurotomy in animal models [38, 39]. While preservation of neurovascular bundles is associated with less smooth muscle apoptosis in rats [39], human studies (in which penile biopsy is not a routine option) are more ambiguous. Two studies (combined $n = 486$) showed no relationship between physician-measured penile length and nerve-sparing status [4, 26], but one ($n = 126$) found nerve-sparing surgery ($p < 0.0001$) and recovery of erectile function ($p = 0.053$) to be independent predictors of a lesser degree of penile shortening at 12 months post-RP [5].

Interestingly, nerve-sparing status and erectile function also appear to influence *perceived* length loss. Men who had unilateral nerve-sparing RP were more likely to report subjective decrease in penile length compared to men who had bilateral nerve-sparing RP (58 vs 33%, respectively; relative risk of 1.8, 95% CI 1.1–2.8) and more men with ED complained of penile shortening, compared with men with no ED, corresponding to a relative risk of 1.7 (95% CI 1.3–2.3) [8]. Another study of 316 RP patients reported significantly lower risk of self-perceived penile shortening (odds ratio 0.32, 95% CI 0.16–0.95) in patients who had nerve-sparing surgery at a median of 17 months postoperative [9]. Whether these findings represent superior length preservation, superior erectile function, or simply altered perceptions based on knowledge of nerve-sparing status is unclear. No studies have compared open prostatectomy and robot-assisted laparoscopic prostatectomy in regard to penile length changes.

Cavernosal Fibrosis

Alternation between flaccidity and erection is thought to be important for regulation of cytokines and vasoactive factors critical for functional connective tissue/smooth muscle ratio in the penis [40]. In the flaccid state, the corpus cavernosum has a lower blood oxygen tension that creates an environment conducive to production of transforming growth factor-β, which in turn induces vascular fibrosis. During an erection, the inflow of arterial blood increases the blood oxygen tension, which favors collagen degradation and reduced connective tissue synthesis. In the absence of adequate oxygenation, collagen accumulates, and progressive fibrosis ensues.

Fibrosis is a common finding in men with post-RP ED [11, 41]. Approximately 41% of men referred for ED after RP have clinically detectable penile fibrotic changes (e.g., shortening, curvature, plaques, and narrowing) at mean 34 months post-RP [41]. Post-RP patients have a reported prevalence of Peyronie's disease (PD) up to 16%, much higher than even the highest estimated general population prevalence of 8.9% [11, 42]. It remains unclear whether these post-RP changes represent a variant form of PD, given the ambiguity inherent in making a clinical diagnosis of PD itself.

Androgen Deprivation

Based on limited data, neoadjuvant androgen deprivation therapy (NADT) does not appear to worsen penile length shortening after RP [25]. A study compared penile length changes before and up to 24 months after RP in 41 patients who received NADT (mean

7 months) versus 102 patients who had RP alone [25]. No length measurement was obtained prior to NADT. Preoperative sexual function was poorer and excised prostate specimens were smaller in the NADT(+) group than in the NADT(−) group. At 10 days after surgery, SPL was significantly decreased in both the NADT(+) and NADT(−) groups (13.7 and 16.9%, respectively). For both groups, penile length returned to preoperative values at 12 months after surgery.

Treating Penile Length Loss After RP

The concept of penile rehabilitation for restoration of erectile function after RP was first published by Montorsi et al. in 1997 [43]. The primary intent of penile rehabilitation is preservation of erectile function, but there has also been interest in rehabilitation for length preservation. Common means for penile rehabilitation include oral phosphodiesterase type 5 inhibitors (PDE5I), intracavernosal and intraurethral vasoactive agents, and mechanical therapy with external vacuum or traction devices. More novel and less well-established modalities include local hyperthermia, botulinum toxin, and surgical penile augmentation.

Pharmacotherapy

PDE5I

Many studies have investigated PDE5I for penile rehabilitation following RP. Although randomized controlled trials have not reliably demonstrated that early PDE5I use improves unassisted erectile function, most studies report that PDE5I are effective in assisting erections on demand [44].

Two small studies designed to address the effect of PDE5I on post-RP penile changes provided evidence that PDE5I can moderate penile length loss [45, 46]. In a single-center, randomized, open-label study, 65 men who underwent bilateral nerve-sparing RP were randomized to tadalafil or no intervention [45]. The control group had significant reduction in length (8–9 mm) and circumference (4–5 mm) in both the flaccid and erect state at 3 months postoperatively (p = 0.001) and a further mean decrease of 7 mm in erect penile length at 6 months compared to 3 months after surgery (p < 0.05). The tadalafil rehabilitation group had no significant reduction in measurement in flaccid or erect state at any intervals. No comparison between groups was reported. Data from another study showed that those who reported "always" using daily PDE5I had no length reduction (n = 36, 1 mm gain; p = 0.37) at 6 months after RP compared with baseline, while those who did not "always" use daily PDE5I had a mean loss of 4.4 mm (n = 27; p < 0.002) [46]. However, this was a nonrandomized trial and the examiner was not blinded to treatment status.

The REACTT trial was a multicenter, double-blind, double-dummy, placebo-controlled study of 423 patients randomized to tadalafil 5 mg once daily, tadalafil 20 mg on demand, or placebo for 9 months, followed by a 6-week washout period, and 3 months of open-label, once-daily tadalafil [47]. Data collected after the 6-week drug washout period showed no significant difference in erectile function between all groups. However, after 9 months of double-blind treatment, the tadalafil once-daily group had lower mean penile length loss (4.1 mm, range 0.4 to 7.8 mm; p = 0.032) compared to the placebo group [47].

Angiotensin Receptor Blockers

A small retrospective study compared a cohort of men without prior ED who underwent nerve-sparing RP and started taking daily irbesartan on postoperative day 1 (n = 17) versus those who refused (n = 12) [48]. Erectile function was monitored by the administration of the International Index of Erectile Function-5 (IIEF-5) questionnaire before surgery and at 3, 12, and 24 months postoperative intervals. SPL was measured immediately and 3 months after RP. The use of erectogenic therapy was not assessed.

While the mean IIEF-5 scores of both groups were similar at 24 months (p = 0.77), the scores of the irbesartan-treated group were significantly higher than those of the control group at 12 months (14 ± 2.6 vs 7.2 ± 1.6, respectively; p = 0.021). This result suggests that irbesartan could accelerate erectile function recovery. At 3 months, men taking irbesartan had a significant reduction in proportional length loss compared with the control group (− 0.9 ± 1.5 vs − 5.6 ± 1.5%, respectively; p < 0.05).

To date, this is the only study that correlated angiotensin receptor blocker (ARB) use to preservation of penile length [48]. The improvement in erectile function and penile length preservation is thought to be mediated by anti-inflammatory and anti-fibrotic effects of ARBs, as shown in animal studies that demonstrated preservation of erectile function in losartan-treated rats postbilateral cavernous nerve crush injury [49].

Intracavernosal Injection and Intraurethral Suppository

Evidence supporting the use of intracavernosal injection (ICI) or intraurethral suppositories of alprostadil (IUA) for penile length preservation is scarce [50]. One study described the changes in penile length in RP patients who were randomized to daily IUA (n = 139) or oral sildenafil daily (n = 73) for 9 months [51]. Both groups initiated treatment within 1 month of surgery. SPL was measured preoperatively, at catheter removal, and at postoperative months 1, 3, 6, 9, 10, and 11. Both groups experienced similar ranges of proportional SPL loss (3

to 7% vs 4 to 7%, respectively) at various time points. Statistical comparisons were not made between the groups.

Mechanical Therapy

Vacuum Erection Device

The vacuum erection device (VED) distends corporal sinusoids via negative pressure and thus increases penile blood flow [52, 53]. Application of vacuum pressure to the penises of rats subjected to cavernous nerve injury has been shown to moderate penile length losses, possibly via decreased collagen deposition and smooth muscle apoptosis [53–55]. In men with ED after RP, VED use has been shown to significantly increase glanular and corporal oxygen saturation for 60 min after removal of the device [56].

A prospective randomized trial compared post-RP penile size changes in men on daily VED treatment ($n = 74$, started at a mean of 4 weeks) and men who did not use a VED ($n = 35$) [57]. Of the treatment group, 14 patients (19%) discontinued VED use. The remaining 60 patients used VED to facilitate penetrative intercourse twice a week on average. Of these 60 patients, 14 (23%) reported a subjective decrease in penile length and circumference at 6 months, compared to 12 of 14 men (86%) who stopped using VED and 22 of 35 men (63%) in the control group. No objective penile measures were performed and the regularity or duration of VED application was not specified.

In an uncontrolled study, 42 men who underwent RP began using VED the day after catheter removal and continued for 90 days with self-tracking of compliance [58]. Three patients dropped out from the study for reasons unrelated to VED use. Of the 36 patients who reported VED use of at least 45 of 90 possible days, 35 patients (97%) preserved their SPL and only 1 patient (3%) experienced a decrease in physician-measured penile length of ≥ 1.0 cm at the 3-month follow-up. Of the 3 patients with significant shortening ≥ 1.0 cm (9 to 17% of total length), 1 patient had used VED for only 23 days and another used VED for only 9 days.

A randomized, controlled trial compared daily, 10-min VED use for 5 months, starting 1 month post-RP ($n = 17$), to on-demand VED use starting at 6 months post-RP ($n = 11$) [59]. Neither group was allowed to use PDE5I until 6 months post-RP. Measurements were obtained by six physicians who were blinded to patient study status. The early initiation group had no significant decrease in SPL at any time point up to 12 months post-RP. In contrast, the late initiation group had a mean loss of 1.87 cm at 3 months (− 3.26 to 0.48; $p = 0.013$) and 1.82 cm (− 3.2 to 0.47; $p = 0.013$) at 6 months. At the last follow-up (mean 9.5 months), the mean loss in the late group was 1 cm (− 2.8 to 0.8), which was not statistically significant compared to baseline ($p = 0.242$).

VED is nonpharmacological, relatively noninvasive therapy with low marginal cost and good durability [60]. Preliminary results suggest some benefit from VED use, but existing data are subject to substantial risk of bias and treatment compliance may be challenging. Larger randomized trials are needed to confirm the efficacy of VED in penile length preservation and to explore the optimal protocol for RP patients.

Penile Traction Device

Prospective studies have mainly studied the application of penile traction devices in men with PD or those complaining of a small penis. A recent randomized controlled trial of 110 men with PD demonstrated improvement in penile length (mean + 1.5 vs 0 cm at 3 months; $p < 0.001$) and curvature (− 11.7° vs + 1.3° at 3 months; $p < 0.01$) in those randomized to daily 30 to 90 min of penile traction device use for 3 months ($n = 63$), compared to controls ($n = 27$) [61]. A randomized controlled trial of the same traction device in post-RP patients is underway [62].

Local Hyperthermia

Application of heat to the penis is a novel therapy which was investigated in a small ($n = 40$) randomized study of men post-RP [63]. It was hypothesized that increased cell metabolism, oxygenation, and venous drainage would promote tissue healing in a fashion similar to what is observed with hyperthermia for musculoskeletal injuries [64, 65]. The treatment group ($n = 20$) was subjected to a total of 20 applications of local hyperthermia, starting at 3 weeks post-RP [63]. During each session, the dorsal surface of the penis was heated at 39 to 40 °C via microwave for 30 min, with temperature monitored by copper thermocouples placed on the skin. The authors used surface temperature as a proxy for corporal temperature. Three months after RP, only the observation group showed a statistically significant reduction in SPL ($p < 0.01$). Sixteen patients (80%) in the hyperthermia arm had no change in physician-measured penile length and the remaining 4 patients (20%) had a reduction ranging between 0.5 and 1.5 cm, whereas 8 patients in the observation arm (40%) had no penile change and 12 patients (60%) had a reduction ranging from 0.5 to 2.5 cm (mean ± SD = 0.8 ± 0.9).

Botulinum Toxin

Botulinum toxin was injected into the dartos muscle of 10 men who complained of small phallus in the flaccid state with the intention of reducing sympathetic retraction [66]. The flaccid, unstretched shaft length increased by a mean of 2.5 mm (+ 7.5% from baseline, $p = 0.0002$), though timing of the measurements was not described. Seven men noticed a

subjective decrease in frequency and magnitude of penile retraction at 3 to 4 weeks after injection. However, stretched penile length and erect length did not change in any of the patients after treatment. No published trials have been conducted on the use of botulinum toxin for penile length preservation/restoration in post-RP patients.

Length Preservation at Penile Prosthesis Implantation

Penile prosthesis implantation offers a definitive solution for ED but has been associated with penile shortening [60, 67, 68]. One prospective study (n = 11) reported mean decreases of 0.83, 0.75, and 0.74 cm in erect penile length at 6 weeks, 6 months, and 1 year after prosthesis implantation, respectively, when compared to baseline erectile penile length induced by ICI ($p < 0.05$) [68]. Interestingly, perception of length loss was reported by up to 71% of men even in the absence of measured penile length loss [67].

Decreased penile length after prosthesis implant may be secondary to intrinsic limitations of the device or capsule development around the cylinder which may restrict circumferential and lengthwise expansion [69]. Lack of glanular engorgement may also lead to a perception of a loss in length. A variety of modalities have been reported for enhancement of penile implant length.

Pretreatment with Traction/VED

A randomized trial reported that regular use of VED prior to prosthesis placement resulted in a statistically significant increase in SPL at the day of surgery when compared to baseline length measured at initial consultation and easier corporal dilatation intraoperatively [69]. Fifty-one patients with severe ED seeking penile prosthesis insertion were randomized to daily VED use for 10 to 15 min for at least 1 month before prosthesis placement (n = 25), or control group with no intervention prior to prosthesis placement (n = 26) [69]. A statistically significant increase in SPL was observed in the VED pretreatment group (mean 0.8 cm; p = 0.02) but not in the control group (mean 0.2 cm; p = 0.104). Surgeons blinded to treatment assignment reported "smooth" corporal dilation more frequently in the VED pretreatment group than in the control group (100 vs 69.2%; p = 0.014). Cavernotome usage was less frequent in the VED pretreatment group compared to the control (0 vs 15.4%; p = 0.001).

Another study investigated the effect of presurgical traction therapy. Ten men with ED refractory to nonsurgical therapy and a complaint of penile length loss, including four men who had undergone RP, applied an external penile traction device for a minimum of 2 h daily for 2 to 4 months before prosthesis placement [70]. Posttraction SPL demonstrated a mean increase of 1.5 cm at the time of prosthesis placement. Postoperative penile length from pubis to corona ranged from 0 to 1.5 cm longer than their baseline pretraction flaccid SPL, with a mean increase of 0.9 cm. Three men had no length gain or loss. All four RP patients had an increase in penile length after prosthesis placement. Adverse events included difficulty applying the device (60%) and pain which tended to decline with use (40%).

Surgical Techniques

A prospective study of 256 penile prostheses placed by 46 surgeons found that corporal dilation may be easier from a trans-scrotal approach with an increased in reservoir fill volume and a 1- to 2-cm increase in length of prosthesis inserted compared to those placed via an infrapubic approach [71]. This study reported no differences in baseline patient characteristics, including the number of patients with prior RP. This study is hampered by the large number of surgeons involved; results may relate to surgeon more so than technique.

A sliding technique of corporal incision and tunical patch at the time of prosthesis placement has been reported as a means to lengthen the penis [72]. In three PD patients, this approach was reported to lead to a mean increase in penile length of 3.2 cm, with no complaints of side effects at a mean follow-up of 13 months. The technique was altered into the "multiple slide technique" and was shown to increase penile length by a mean of 3.1 cm (ranging 2 to 5 cm) in 138 patients with penile shortening, including 14 whose length reduction occurred post-RP [73]. In the mean follow-up period of 15.2 months, 1 case of glans necrosis was noted. Sliding techniques require extensive mobilization of the neurovascular bundle and the urethra; legitimate concerns exist about potential penile narrowing, neuronal injury, or in the worst-case scenario compromise of distal vascular supply and glans necrosis, which may be particularly salient in the case of prior RP [74].

The timing of penile implant is a source of some concern; given the possibly progressive nature of penile fibrosis [37], it is conceivable that earlier penile implant placement may improve outcomes. Taken to an extreme, penile prosthesis placement was described as a simultaneous procedure at the time of RP in a study of 50 men [75]. Forty-eight men (96%) reported having sexual intercourse at a mean time of 12.7 weeks after surgery and 17 men (35%) initiated intercourse within 8 weeks. At a mean follow-up of 1.7 years, no prosthesis infections were reported. A comparison to 72 patients undergoing RP alone by the same surgeon showed no difference in estimated blood loss, hospital length of stay, and postoperative analgesic use. In another case series of 10 men undergoing simultaneous laparoscopic extraperitoneal RP and penile prosthesis implantation, no significant length difference was noted between the time of surgery and up to 2 years after prosthesis implantation [76]. A reduction of 0.5 cm was noted in only

20% of the patients. No prosthesis infections occurred over a median follow-up of 32 months.

Ultimately, penile prosthesis surgery should be utilized as a means to restore erectile function rather than a means to regain penile length. Additional, larger studies on methods to safely maintain or even improve penile length are required. For the time being, traction therapy and vacuum therapy appear to present minimal risk. However, benefits remain ambiguous. Compliance to protocol required for even minor length changes can be challenging.

Penile Augmentation

Injection of various substances, including liquid silicone, polyacrylamide, and hyaluronic acid, into the phallus poses as a technically simple and often patient-administered penile augmentation strategy [77]. However, there exist great concerns for infection, granulomatous reaction, and damage to the neurovasculature related to injection of foreign body [77, 78].

Injection of nonabsorbable polymethylmethacrylate (PMMA) between the dartos fascia and Buck's fascia in 20 patients has been shown to increase unstretched, flaccid length by a mean of 2.3 cm (63.2%; $p < 0.0001$) at 6 months after injection [79]. The increase in length was maintained at the 12- and 18-month follow-up with no adverse effects documented with the exception of one complaint of a nodule [80]. A much larger study ($n = 203$) reported an average increase of 0.7 cm in in-office measurement of flaccid penile length after PMMA injections [81]. Evidence for efficacy of injectable agents in RP patients is scant.

Surgical options for penile augmentation include autologous fat grafting and dermal acellular grafts. These procedures are also prone to infectious complications, and the cosmetic and functional results may leave the patient dissatisfied [78, 82]. Aside from augmentation procedures, surgical procedures such as suspensory ligament release, V-Y advancement, and suprapubic lipectomy have been proposed as means to increase *functional* penile length without specifically addressing actual phallic length. These procedures were recently reviewed by Campbell et al. [77]. While various procedures have been associated with small (1 to 2 cm) changes in penile length, patient dissatisfaction tends to remain high [78]. Surgical procedures for penile length enhancement should be utilized with great caution. The Sexual Medicine Society of North America states that penile enhancement surgery should be treated as experimental in men who do not have congenital anatomical anomalies of the penis [83]. Careful patient selection and counseling is essential [84].

Conclusion

Loss of penile length after RP can pose as a source of great concern for patients. Appropriate management should include careful preoperative counseling and expectation setting. After RP, treatments for preserving erectile function and penile length may be used judiciously, but patients must be informed of the limited evidence basis for all of these.

Compliance with Ethical Standards

Conflict of Interest Dr. Lai declares no conflicts of interest. Dr. Shindel reports roles as board member of Sexual Medicine Society of North America, associate editor of International Society of Sexual Medicine, and personal fees from Genomic Health, outside of submitted work.

Research Involving Human Participants and/or Animals This article does not contain any studies with human or animal subjects performed by the author.

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