Penile Length: Measurement Technique and Applications

Ethan P. Davoudzadeh, BS,[1] Natan P. Davoudzadeh, MD,[2] Ezra Margolin, MD,[3] Peter J. Stahl, MD,[3] and Doron S. Stember, MD[2]

ABSTRACT

Introduction: Penile size has long been an important fixation in men's lives. On the one hand, a smaller penis has been associated with anxiety and apprehension; on the other hand, a larger penis has generally been related to virility and strength. These perceptions predominate during an erection, when penile size is representative of a man's masculinity.

Aim: To assess adult penile length and summarize average penile length assessments from the literature; analyze how various urologic diseases and therapies affect penile length and volume; and review how surgical treatments for Peyronie's disease, penile prosthesis implantation, and radical prostatectomy can affect penile size to appropriately counsel patients seeking such therapies and set realistic goals for patients.

Methods: To achieve the aim of this review, we analyzed the literature on penile size and volume and how these can be affected by various urologic diagnoses and therapies. We summarize common diagnoses and therapies that can affect penile size.

Main Outcome Measure: We thoroughly discuss how the aforementioned diagnoses and therapies can negatively affect penile size. In doing so, we allow readers to understand the intricacies of penile size when faced with such diagnoses and therapies in their patients.

Results: Surgical treatments for Peyronie's disease, penile prosthesis implantation for refractory erectile dysfunction, and radical prostatectomy for prostate cancer can lead to a decrease in penile size.

Conclusion: Urologists must recognize that the different therapies they offer can affect a man's penile size, often negatively. This in turn can lead to poorer satisfaction outcomes in patients. **Davoudzadeh EP, Davoudzadeh NP, Margolin E, et al. Penile Length: Measurement Technique and Applications. Sex Med Rev 2018;6:261–271.**

Key Words: Penile Size; Penile Volume; Peyronie's Disease; Inflatable Penile Prosthesis; Radical Prostatectomy; Plaque Incision and Grafting

INTRODUCTION

Men and women have had a fascination with penile size throughout recorded history. Penile size has traditionally been associated with increased sexual prowess, virility, and vigor in men.[1] There are many methods men have used to enhance their penile length dating back to ancient times. The Sadhus men of India and the Cholomec tribe in Peru attached weights to augment their penile lengths.[2] In addition, in the 16th century, the Topinama tribe of Brazil allowed their penises to be bitten by poisonous snakes in the hopes of enlarging them through the subsequent swelling that would inevitably occur.[3]

A larger penis has been closely aligned with significantly higher self-esteem in men.[4] It seems, perhaps unexpectedly, that men are more concerned with penile length than women. It has been illustrated through surveys of more than 52,000 subjects that 85% of women were satisfied with their partner's penis size. However, only 55% of men were satisfied with their own penis size, portraying an evident contrast.[4] In fact, the *Diagnostic and Statistical Manual of Mental Disorders* has defined an excessive fixation on one's penile length as genital retraction syndrome.[5,6] Men with this syndrome have a fixed belief that their genitals are getting smaller and eventually will disappear, despite the absence of actual quantifiable change in their penile length.[6]

Although it is clear that penile length is essential to the male psyche, penile length is not related to the normal functioning of

Received June 13, 2017. Accepted October 6, 2017.

[1]SUNY Downstate College of Medicine, Brooklyn, NY, USA;

[2]Department of Urology, Icahn School of Medicine at Mount Sinai, New York, NY, USA;

[3]Department of Urology, Columbia University Medical Center, New York, NY, USA

https://doi.org/10.1016/j.sxmr.2017.10.002

the penis in procreation or urination. For this reason, the effects of certain urologic diseases and therapies that affect penile size must be well understood to successfully counsel patients and manage their urologic problems. In this review, we assess how different urologic diseases and therapies can affect penile size and volume.

MEASUREMENT OF PENILE VOLUME, LENGTH, AND CURVATURE

There are 2 main phases of penile growth and development. The first phase of rapid growth and development occurs mainly from birth until 5 years of age. The second phase of rapid growth occurs mainly from puberty until 17 years of age.[7] This review concentrates principally on the adult penile size.

Multiple methods have been described and used to objectively determine stretched flaccid penile length. Nonetheless, it is important to remember that, with any measurement modality, certain factors such as level of arousal and room temperature can cause alterations to penile length for a given patient. These measurements typically should be performed with a flaccid penis status. During measurement, a partial or full erection should be recorded to avoid confusing the results with flaccid penile length. In addition, other factors that can alter penile dimensions include cold temperature and recent ejaculation, which can be noted.[8] Most studies define stretched flaccid penile length as the linear distance along the dorsal side of the penis extending from the pubo-penile skin junction to the tip of the glans, with the penile circumference being measured at the middle of the shaft.[8–10]

The glans penis should be held in gentle traction with the patient in the supine position, with the observer's other hand holding a ruler placed at the base of the penis and along the dorsal aspect of the shaft. These measurements are frequently reported in millimeters or centimeters, not inches. An ideal method for such measurements is the use of simple plastic rulers, which should be wiped thoroughly clean by antiseptic solution between uses. Commercially available disposable penile measurement rulers also can be obtained (UroSciences, Inc, Jericho, NY, USA). Several studies have documented average penile sizes (Table 1). In these studies, which pooled average penile sizes of more than 15,000 men, the average penile length in the flaccid, stretched flaccid, and erect states were 9.16, 13.24, and 12.12 cm, respectively.[8] The average flaccid and erect circumferences at mid-shaft were 9.31 and 11.66 cm, respectively.[8]

The evaluation of any penile curvature or deformity is another significant measurement of the human penis that should be performed. Making an accurate assessment is important because it can influence management options, assessment of changes after treatment, and for research purposes. There are multiple techniques that can be used to measure penile curvature including at-home photography, the vacuum erection device, and intracavernosal injection (ICI) and goniometer in the physician's office. Ohebshalom et al[11] showed that the gold standard method

Table 1. Summaries of studies on penile size

Study	Country	Patients, n	Age (y), mean (range)	Flaccid length (cm), mean (SD)	Flaccid circumference (cm), mean (SD)	Stretched length (cm), mean (SD)	Erect length (cm), mean (SD)	Erect circumference (cm), mean (SD)
Ajmani et al, 1985[75]	Nigeria	320	NR (17–23)	8.16 (0.94)	8.83 (0.02)	NR	NR	NR
Wessels et al, 1996[14]	USA	80	54 (21–82)	8.85 (2.38)	9.71 (1.17)	12.45 (2.71)	12.89 (2.91)	12.30 (1.31)
Ponchietti et al, 2001[76]	Italy	3,300	NR (17–19)	9.0 (2.0)	10.0 (0.75)	12.5 (2.5)	NR	NR
Schneider et al, 2001[77]	Germany	111	NR (18–19)	8.60 (1.50)	NR	NR	14.48 (1.99)	NR
Sengezer et al, 2002[78]	Turkey	200	21.2 (20–22)	6.80 (0.08)	NR	8.98 (0.09)	12.73 (0.11)	NR
Savoie et al, 2008[62]	USA	124	59.1 (42–76)	9.3 (2.0)	9.4 (1.4)	17.5 (2.6)	NR	NR
Awwad et al, 2004[79]	Jordan	271	44.6 (17–83)	9.3 (1.9)	8.98 (1.4)	13.5 (2.3)	NR	NR
Promodu et al, 2007[9]	India	301	31.58 (18–60)	8.21 (1.44)	9.14 (1.02)	10.88 (1.42)	12.93 (1.63)	11.49 (1.04)
Soylemez et al, 2011[80]	Turkey	2,276	21.1 (18–39)	8.95 (1.04)	8.89 (0.86)	13.98 (1.58)	NR	NR

NR = not reported.

in determining penile curvature or deformity is by inducing artificial erections through the use of ICIs of vasoactive agents and then using a goniometer to measure the degree of curvature or deformity. Further, patient self-assessment of any curvature has been shown to be inadequate in documenting the magnitude of deformity, because of the poor correlation between subjective self-assessment and objective physician measurement of curvature.[12]

In addition, the measurement of penile volume can be an important tool for the diagnosis and management of penile disorders, including erectile dysfunction (ED), Peyronie's disease (PD), and congenital penile curvature. Volume measurements have historically been difficult to obtain because of technologic limitations, and investigators have explored different methods to measure penile volume. Some studies have used external measurements of penile circumference and length to approximate volume using a cylindrical model.[13,14] Others, such as Chen et al,[15] calculated penile volume in patients with ED using ultrasonography to measure the radius of the corpora cavernosa before and after prostaglandin injection. By measuring penile length from base to mid-glans, they used the cylindrical approximation $\pi \times r^2 \times l$ to calculate the volume of each corpus. The summation of the volume of the 2 corpora was taken as the total penile volume. A similar cylindrical approximation using the radius of the corpora cavernosa was used by Nelson and Lue.[16] Penile volume also has been calculated as a function of cavernosal expandability, tunica distensibility, and intracavernosal pressure.[17]

An alternative approach to measuring penile volume is to measure penile blood volume. This has been explored in several studies using labeled blood-pool techniques, intracavernosal tracer washout, and xenon washout, with volumes calculated based on measurements from non-image scintillation probes.[18–22] The probe system is limited by its inability to restrict measurement to only the penis and not the surrounding tissues, because shielding the surrounding tissues is technically challenging.[21] Nocturnal electro-bioimpedance volumetric assessment, which has been validated in patients with and without ED, applies an undetectable alternating current to a tissue segment and measures the potential difference between 2 electrodes. The measurement of tissue impedance between electrodes in the penis allows for the calculation of penile blood volume, penile length, and cross-sectional area.[23,24]

Recently, 3-dimensional photography has been used in the measurement of penile volume. In a proof-of-concept study, Margolin et al[25] used a 3-dimensional camera to capture images of plastic penis models with deformities simulating those found in men with PD. The images were subjected to computer analysis to measure various parameters including penile volume. In all models, this technique was found to obtain accurate measurements of penile volume as validated by water displacement testing. Although many other methods of penile volume measurement rely on cylindrical approximations that require uniformity, 3-dimensional photography with computerized analysis allows direct volume measurement that is better suited for patients with PD or congenital penile curvature.

INFLATABLE PENILE PROSTHESES AND EFFECTS ON PENILE SIZE

ED is defined as an inability to develop or sustain an erection appropriate for sexual performance. In the United States, this disorder has a prevalence of up to 52% in men 40 to 70 years old, with increasing prevalence in older age as demonstrated by the Massachusetts Male Aging study.[26] Moreover, the National Institutes of Health estimated that approximately 30 million men in the United States have ED.[27]

There are many medications available to men with ED. However, for men who do not benefit from medical treatment, the surgical standard of care is insertion of an inflatable penile prosthesis (IPP). Patient counseling is extremely important in the preoperative period to set realistic expectations because the outcome of the procedure is largely dependent on patient and partner satisfaction.

To set realistic expectations for patients, measurements from pharmacologically induced erect penile length and stretched penile length are good predictors of penile length postoperatively.[28] However, most men (72%) report a subjective loss in penile length after IPP, although there might be no objective measurable loss as reported by Deveci et al.[29] Similarly, Wang et al[30] reported a significant decrease in erect penile length after IPP implantation compared with that after ICI. The mean penile length with PPI was 12.5 cm compared with 13.2 cm induced by ICI, suggesting a mean erect length loss of 0.7 cm.[30] For this reason, it is imperative that patients are counseled before the procedure and warned that not only will there no increase in penile length, as many patients erroneously assume, but that there could be a potential loss in penile length. Once adequately counseled, patients should proceed with the procedure only if they are willing to accept this possibility.

Multiple theories have been set forth as to why patients might perceive or experience a loss of penile length after IPP surgery. First, many potential candidates for IPP might have developed corporal fibrosis or scarring because they likely have not experienced rigid erections for a prolonged period before surgery. The corporal fibrosis or scarring in turn restricts the elasticity of the tunica albuginea, limiting the size of the prosthesis that can be inserted and thus potentially shortening penile length.[31] However, the loss in penile length is not perceived until the patient again experiences IPP-induced rigid erections. Second, the lack of glanular engorgement can lead to a perception of loss in penile length because penile prostheses do not affect glanular engorgement compared with natural erections.[31] Third, as noted earlier, IPP candidates typically have not had rigid erections for quite some time before surgery; for this reason, their subjective recollection of their true penile size before developing ED is

often inaccurate. Fourth, men can attain pannus fat as they get older, which gives the appearance of a partly buried penis.[31]

Although there have been studies to demonstrate the shortening of penile length after IPP surgery, there are techniques that have been developed that have shown the opposite. The "sliding technique" during IPP surgery has been described by Rolle et al[32] in which the IPP is combined with a double-dorsoventral patch graft to lengthen the penis. In this technique, an incision is made into the tunica albuginea to relax and lengthen the penis after which the IPP cylinders are inserted. The final step involves using porcine small intestinal submucosa in the grafting component to cover the tunica defects made. They performed this technique in 3 patients with PD and penile shortening and showed an average increase in length of approximately 3.2 cm at follow-up of 13 months. There was no significant loss of sensitivity or signs of impaired vascularity in this case series.

Furthermore, Egydio and Kuehhas[33] described a modified "sliding technique" for penile length gain and girth restoration with concomitant IPP implantation. This technique is based on 3 main components: (i) the sliding maneuver to increase penile length as described earlier, (ii) potential complementary longitudinal ventral and/or dorsal tunica incisions for girth restoration, and (iii) closure of the newly created rectangular bow-shaped tunica defects with Buck fascia. In this study, 143 patients underwent this procedure, which showed a mean penile length increase of 3.6 cm (range = 2−7cm) at a median follow-up of 9.7 months with no major intraoperative or postoperative complications.[33] Similarly, a multicenter prospective study by Sansalone et al[34] looked at the effect of circumferential grafting and tunica incision during IPP insertion on penile length in patients with PD and severe penile shortening. This study showed an average penile length gain of 2.8 cm with average follow-up of 22 months and 90% of patients reported satisfaction with the cosmetic and functional results of the surgery. Using a sub-coronal approach for IPP insertion, Weinberg et al[35] and Gaffney et al[36] found that mean cylinder size increased from 20.4 to 22.1 cm. Tran et al[37] reviewed the results from several novel techniques for penile length preservation and enhanced during IPP surgery and found such techniques to be safe and effective in preserving and/or increasing penile length at time of IPP insertion.

PEYRONIE'S DISEASE

PD is due to the development and accumulation of collagen in the tunica albuginea of the corpora cavernosa. This disease is seen in up to 3% to 9% of men, affecting their quality of life and often leading to depression, low self-esteem, and fear of sexual activity.[38,39] PD also can be associated with ED, penile nodular induration, penile curvature, and loss of penile girth and length.[40] For this reason, penile shortening is a common symptom seen in approximately 1 third of patients with a diagnosis of progressive PD.[41]

There are 2 distinct phases of PD. The first phase, or acute inflammatory phase, which can last up to 6 to 18 months, consists of the development of painful penile plaques resulting in progressive penile curvature. The second phase, or chronic phase, is characterized by a stable painless penile deformity. Many different treatment options are available for PD, including surgical and non-surgical. Non-surgical options include observation, oral pharmacotherapy, and intralesional injection therapy. The goal of treatment is to repair any penile deformity, maintain penile length, and enable the patient to accomplish and sustain an erection for sexual intercourse.[42] In this review, we highlight the surgical treatment options for PD with a particular focus on how they can affect penile size.

Surgical management of PD should be considered only in patients who prefer definitive treatment or in patients for whom medical therapy has been ineffective. Additional indications for surgical management include patients who have a stable deformity with painless erections for at least 3 months, extensive plaque calcifications, and a deformity that precludes sexual intercourse.[42,43] There are numerous surgical options for PD, such as penile plication, plaque incision or excision and grafting, and IPP surgery with or without modeling, plication, or incision and grafting techniques. With all these options, the surgical approach must be based on individual patient factors such as the degree and nature of the deformity, penile length, and degree of erectile function.

A plication procedure, also known as a shortening procedure, is most commonly used in men with normal erectile function, penile length sufficient for sexual intercourse, uniplanar penile curvature less than 60°, and absence of hourglass deformity or hinge.[44] There are different types of plication procedures that have been described and are presented in Table 2. A plication procedure usually shortens the convex side of the curved penis so that it matches the shortened side in length, thereby removing the observed curvature. One of the most common complications after any type of plication procedure is loss of penile length. After a plication procedure, penile length can be approximated using a string held against the concave edge of the curved erect penis. Factors associated with predicting loss of penile length after a plication procedure are direction of curvature and degree of curvature.[45] Andrews et al[46] found that 39% of patients experienced penile shortening greater than 2 cm after a Nesbit plication procedure. Furthermore, Licht and Lewis[47] showed that 67% of patients experienced penile shortening after a modified Nesbit plication procedure, whereas 37% of patients experienced penile shortening after a standard Nesbit plication procedure. Results from multiple studies including surgical outcomes are presented in Table 2.

Another surgical modality commonly used to treat PD is a tunica lengthening procedure, also called plaque incision or excision with grafting. Plaque incision and grafting procedures consist of making an incision in the plaque at the point of maximum curvature on the convex side of the penis followed by

Table 2. Penile plication procedures

Procedure	Study	Patients, n	Mean follow-up (mo)	Surgical outcomes, %					
				Straightening	Shortening	Postoperative ED	Sensory change	Pain	Satisfaction
Tunica albuginea plication	Paez et al, 2007[81]	760	70.5	42.1	NR	60.5	65.8	27.6	NR
	Taylor et al, 2008[82]	61.0	72.0	93.0	18.0	10.0	31.0	NR	84.0
Nesbit	Syel et al, 2003[83]	57.0	84.0	61.9	50.0	12.2	21.4	NR	76.2
Yachia procedure	Daitche et al, 1999[84]	19.0	24.1	93.0	57.0	7.1	0.0	0.0	79.0
	Rehman et al, 1997[85]	26.0	22.0	73.1	73.1	23.1	19.2	NR	77.0
16- or 24-dot procedure	Gholami et al, 2002[86]	132.0	range = 6.0–30.0	93.0	41.0	NR	6.0	11.0	96.0
Penoscrotal plication	Dugi et al, 2010[87]	48.0	4.0–6.0 wk	93.0	0.0	NR	0.0	6.0	93.0
Tunica plication + plaque thinning	Ding et al, 2010[88]	18.0	50.5	83.3	66.7	0.0	NR	NR	100.0

ED = erectile dysfunction; NR = not reported.

placement of a graft to lengthen the penis and repair any defect.[48,49] Plaque excision and grafting procedures consist of complete or partial surgical excision of the plaque followed by replacement of the calcified area of the tunica by a graft. Partial plaque excision is more commonly associated with a decreased risk of irreversible erectile tissue damage and permanent postoperative ED.[50] Plaque incision and grafting procedures are believed to involve a lower risk of penile shortening compared with plication procedures. Nonetheless, these procedures can still be associated with significant rates of penile shortening. El-Sakka et al[51] analyzed 112 patients after undergoing a plaque incision and venous patch grafting procedure and found that 16.9% of patients did experience a loss of penile length. Moreover, Kalsi et al[52] showed that although 93% of their patients had satisfactory results and 86% had a completely straightened penis after a plaque incision and venous grafting procedure, there was still a significant portion of patients (25%) who experienced more than 1 cm of penile shortening after the operation. In another study, Montorsi et al[53] showed that 40% of patients reported penile length shortening after a plaque incision and grafting procedure. Conversely, Yurkanin et al[54] analyzed the effects of incision and saphenous vein grafting for PD on penile length and found that in all 22 patients who underwent the procedure and subsequent follow-up, there was a statistically significant increase in mean penile length by 2.1 cm as a result of surgery. In addition, in the study by Montorsi et al,[53] 60% of men did note a penile length equal to or greater than their penile length preoperatively. Published surgical outcomes, including rates of penile shortening, for various plaque incision and excision with graft procedures are presented in Table 3.

IPP surgery is often recommended for patients who have PD curvature and ED or a profound instability of the penis even with satisfactory erectile function.[55] Adjunctive procedures can be used with IPP surgery to lessen penile curvature. These procedures include modeling,[56] plication,[57] plaque-releasing incisions with or without a graft,[55] and the surgical "scratch" technique.[57] Outcomes related to these procedures are presented in Table 4.

RADICAL PROSTATECTOMY

The second leading cause of cancer-related death and the most common non-skin cancer is prostate cancer. The American Cancer Society estimated that approximately 161,360 new diagnoses of prostate cancer will be made in 2017 in the United States and that it will claim the lives of approximately 26,730 men.[58] 1 in 7 men will be diagnosed with prostate cancer during the course of their lifetime.[58]

Radical prostatectomy (RP) has become one of the most common treatment methods for prostate cancer. Common risks of RP include bleeding, infection, ED, urinary incontinence, and penile shortening. For example, a study by Parekh et al[59] showed that patients, after RP, perceived a decrease in penile size and that

Table 3. Graft materials used in Peyronie's disease reconstructive surgery and surgical outcomes

Procedure or graft	Study	Patients, n	Mean follow-up (mo)	Surgical outcomes, %					
				Straightening	Shortening	Postoperative ED	Sensory change	Pain	Satisfaction
Dermal graft	Chung et al, 2010[89]	6	101.8	50.0	17.0	Significantly less than preoperative ED	13.0	NR	35.0
Tutoplast*		23	79.2	87.0	17.0		NR	NR	NR
SIS		17	75.5	76.6	29.0		NR	NR	NR
Cadaveric pericardial graft	Levine et al, 2003[90]	40	22.0	98.0	33.0	30.0	2.0	NR	NR
Dermal flap	Simonato et al, 2010[91]	22	95.0	63.6	NR	31.8	NR	NR	40.9
TachoSil†	Horstmann et al, 2011[92]	43	63.0	84.0	93.0	2.3 of 4 (EHS)	16.0	7.0	51.0
Buccal mucosa	Cormio et al, 2008[93]	15	13.1	100.0	0.0	0.0	0.0	NR	93.3
Venous patch	El-Sakka et al, 1998[94]	112	18.0	96.0	17.0	12.0	10.0	6.2	92.0
Human pericardial	Taylor et al, 2008[82]	81	58.0	91.0	33.0	32.0	31.0	NR	75.0
Rectus sheath	Craatz et al, 2006[95]	12	4–10	100.0	NR	0.0	NR	NR	58.3
Tunica vaginalis	O'Donnell et al, 2007[96]	25	42.2	88.0	96.0	68.0	16.0	NR	NR
Dermal graft	Goyal et al, 2008[97]	11	6–24	81.8	NR	9.1	18.2	0.0	81.8
Porcine 4-layer SIS	Knoll et al, 2007[98]	162	38.0	91.0	5.0	21.0	17.0	0.0	NR

ED = erectile dysfunction; EHS = Erection Hardness Score; NR = not reported; SIS = small intestinal mucosa.
*Tutoplast is (Mentor Corp, Santa Barbara, CA, USA) a commercially available, modified human fascia lata that can act as a scaffold to allow tunica regeneration.[62]
†TachoSil (surgical patch; Takeda Pharmaceuticals International GmbH, Zurich, Switzerland) combines the bioactive mechanism of action of human coagulation factors, fibrinogen, and thrombin with the mechanical support of a (equine) collagen patch.[52]

Table 4. Penile prosthesis implantation

Procedure	Study	Patients, n	Mean follow-up (mo)	Surgical outcomes, %					
				Straightening	Shortening	Postoperative ED	Sensory change	Pain	Satisfaction
Inflatable penile prosthetic implantation	Levine et al, 2010[99]	90	49.0	4.0	3.0	NR	2.0	NR	84.0
	Levine et al, 2000[55]	46	39.0	100.0	7.0	0.0	9.0	NR	NR
Soft, silicon, axially resistant, prosthetic implantation	Austoni et al, 2005[100]	80	113.0	100.0	NR	0.0	5.0	7.5	95.0
Soft, silicon, dynamic anti-extrusion prosthetic implantation	Grasso et al, 2008[101]	12	72.0	100.0	NR	100.0	NR	NR	91.0
Trans-corporeal incision	Shaeer et al, 2010[102]	16	14.0	100.0	NR	100.0	0.0	NR	100.0

ED = erectile dysfunction; NR = not reported.

Table 5. Penile length changes after radical prostatectomy

Study	Year	Patients, n	Interval	Main outcomes
Carlsson et al	2012	1,411	24.2 mo	55% of patients reported self-perceived penile shortening
Engel et al	2011	127	11 mo	0.64-cm shortening at 1 mo; no decrease in length observed at ≥9 mo
Gontero et al	2007	126	1 y	1.34-cm shortening of flaccid length; 2.30-cm shortening in stretched length
Briganti et al	2007	33	6 mo	No statistically significant length changes in flaccid and erect states
Savoie et al	2003	63	3 mo	19% had 15% shortening of stretched length; 1.2-cm shortening of flaccid length; 1.1-cm shortening of stretched length
Munding et al	2001	31	3 mo	13% had increased stretched length; 16% had no change in stretched length; 71% had decreased length: up to 0.5 cm in 23%, 1.0–2.0 cm in 35%, >2.0 cm in 13%
Fraiman et al	1999	100	1.7–27.6 mo	8% had decrease in flaccid length; 9% had decrease in erect length; greatest change at 4–8 mo

it was significantly associated with emotional disturbances and regret of treatment. As presented in Table 5, changes in penile length have been well recognized after RP.

A study by Munding et al[60] found that after RP, most men (71%) had a statistically significant decrease in penile length with a greater than 1-cm decrease in 48% of these men. A significant decrease in all penile dimensions, including decreased penile length and decreased volume in the flaccid and erect states after RP, was reported by Fraiman et al.[61] The most substantial changes were noted in the first 4 to 8 months after surgery. Similar results were noted by Savoie et al,[62] with 68% of patient having a decrease in stretched penile length 3 months postoperatively.

Penile length was studied by Engel et al[63] after robot-assisted RP, which demonstrated a median penile shortening of 0.64 cm 1 month postoperatively. However, they found that 9 months postoperatively, the penile length had returned to the preoperative measurement.[63] A potential reason for this finding can be due to the fact that the penis is normally in a state of balance between parasympathetic (which causes tumescence and richly innervates the cavernosa) and sympathetic (which causes detumescence) nervous signaling.[64] The cavernous nerves are often injured during RP; therefore, the unopposed sympathetic action can contribute to the exaggerated detumescence in the early postoperative period.[64] It is postulated that over time there is some recovery of the cavernous nerves, which could account for the findings described earlier.[65] In the same way that unopposed sympathetic innervation of the penis could explain penile shortening in the immediate post-RP period, it has been shown to be independently associated with erectile function outcome and nerve preservation status in the postoperative period.[66] Carlsson et al[67] found an association between an extensive nerve-sparing surgical technique and less self-perceived penile shortening, although actual penile lengths were not measured. Conversely, Briganti et al[68] found no statistically significant difference between preoperative and postoperative measurements in penile length and girth in the erect and flaccid states in patients who underwent bilateral nerve-sparing RP.

Another potential theory that tries to explain the decrease in penile length after RP postulates that removal of the prostate and surgical attachment of the bladder neck directly to the pendulous urethra can contribute to the loss in penile length because the prostatic urethra, which previously intervened between the newly anastomosed segments, has been removed. However, it should be noted that the bladder neck is brought down to the penile urethra; the penile urethra is not mobilized toward the bladder. Moreover, it has been shown that prostatic urethra length does not relate to measured penile length.

Yet another proposed mechanism attributes the development of penile fibrosis, from prolonged and profound ED, to cavernosal contraction and penile shortening. As described previously, ED can occur after RP because of damage to the neurovascular bundle, which is responsible for initiating erections. Even with bilateral nerve-sparing RP, ED lasting up to 9 to 12 months can be seen in patients because of mild neurapraxia.[64] Nocturnal erections might be absent or diminished throughout this period of neurapraxia, resulting in persistent penile hypoxia.[64]

One of the most important factors leading to the development of cavernosal fibrosis is penile hypoxia. Regular tissue oxygenation is supplied to the penis through normal erectile function. Nocturnal erections have been shown to preserve normal erectile function and are therefore essential to regular tissue oxygenation. For this reason, it has been theorized that the absence of nocturnal erections in the early postoperative period leads to decreased tissue oxygenation, resulting in the development of fibrosis.[69]

Injury to the cavernous nerve also has been shown to result in apoptosis of corporal smooth muscle[70] and sympathetic hyperinnervation leading to the development of fibrosis.[71] Iacono et al[72] performed biopsies of the corpora cavernosa before RP and 2 and 12 months postoperatively. At the 2- and 12-month postoperative period, there was an increase in the amount of disorganized collagen content with a corresponding decrease in elastic smooth muscle bundles when compared with the preoperative biopses.[72] In patients after RP who were undergoing initial ICI treatment for ED, Mulhall[73] showed an increased rate in the development of PD.

Hall et al[74] found that penile shortening is not only related to surgical treatments for prostate cancer. In this study, changes in penile length were observed in men undergoing a combination of androgen suppression and radiation therapy. Men being treated in this manner had a statistically significant decrease in penile length. There is some evidence, although limited, that external-beam irradiation can result in penile fibrosis and eventually penile shortening.[74] In addition, for men who are undergoing androgen ablation, loss of penile length is common.[74]

CONCLUSIONS

Penile length or size has long been linked to entities such as self-esteem, sexual identity, and virility. It is the subject of major concern to men across various cultures. Urologists must recognize this fact and therefore be familiar with how the various urologic conditions, therapies, and surgeries they offer can affect the penile size and shape of their patients. The loss of penile length could be associated with devastating psychological consequences. The association of real or perceived length loss with surgical procedures for PD, prostate cancer, and ED must be appreciated by practitioners to counsel their patients appropriately preoperatively.

Corresponding Author: Doron S. Stember, MD, Department of Urology, Mount Sinai Hospital, New York, NY, USA. E-mail: doronstember@gmail.com

Conflicts of Interest: The authors report no conflicts of interest.

Funding: None.

STATEMENT OF AUTHORSHIP

Category 1

(a) Conception and Design
Peter J. Stahl; Doron S. Stember

(b) Acquisition of Data
Ethan P. Davoudzadeh; Natan P. Davoudzadeh; Ezra Margolin

(c) Analysis and Interpretation of Data
Ethan P. Davoudzadeh; Peter J. Stahl; Doron S. Stember

Category 2

(a) Drafting the Article
Ethan P. Davoudzadeh; Natan P. Davoudzadeh; Ezra Margolin

(b) Revising It for Intellectual Content
Ethan P. Davoudzadeh; Peter J. Stahl; Doron S. Stember

Category 3

(a) Final Approval of the Completed Article
Ethan P. Davoudzadeh; Natan P. Davoudzadeh; Ezra Margolin; Peter J. Stahl; Doron S. Stember

REFERENCES

1. Veale D, Miles S, Read J, et al. Phenomenology of men with body dysmorphic disorder concerning penis size compared to men anxious about their penis size and to controls: a cohort study. **Body Image 2014;13:53-61.**
2. Vardi Y, Harshai Y, Gil T, et al. A critical analysis of penile enhancement procedures for patients with normal penile size: surgical techniques, success, and complications. **Eur Urol 2008;54:1042-1050.**
3. Talalaj JTS. The strangest human sex, ceremonies and customs. Melbourne, Australia: Hill of Content; 1995. p. 100-102.
4. Lever J, Frederick DA, Peplau LA. Does size matter? Men's and women's views on penis size across the lifespan. **Psychol Men Masc 2006;7:129-143.**
5. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th ed. Arlington, VA: American Psychiatric Publishing; 2013.
6. Mattelaer J, Jilek W. Koro—the psychological disappearance of the penis. **J Sex Med 2007;4:1509-1515.**
7. Barnes HV. Physical growth and development during puberty. **Med Clin North Am 1975;59:1305-1317.**
8. Veale D, Miles S, Bramley S, et al. Am I normal? A systematic review and construction of nomograms for flaccid and erect penis length and circumference in up to 15,521 men. **BJU Int 2015;115:978-986.**
9. Promodu K, Shanmughadas KV, Bhat S, et al. Penile length and circumference: an Indian study. **Int J Impot Res 2007; 19:558-563.**
10. Aslan Y, Atan A, Aydın O, et al. Penile length and somatometric parameters: a study in healthy young Turkish men. **Asian J Androl 2011;13:339-341.**
11. Ohebshalom M, Mulhall J, Guhring P, et al. Measurement of penile curvature in Peyronie's disease patients: comparison of three methods. **J Sex Med 2007;4:199-203.**
12. Matsushita K, Stember DS, Nelson CJ, et al. Concordance between patient and physician assessment of the magnitude of Peyronie's disease curvature. **J Sex Med 2014;11:205-210.**
13. Virag R, Bouilly P, Virag H. Dimensions, volume and rigidity of the penis. Fundamental elements in the study of the erection and its dysfunctions. **Ann Urol (Paris) 1986;20:244-248.**
14. Wessells H, Lue TF, McAninch JW. Penile length in the flaccid and erect states: guidelines for penile augmentation. **J Urol 1996;156:995-997.**
15. Chen KK, Chou YH, Chang LS, et al. Sonographic measurement of penile erectile volume. **J Clin Ultrasound 1992; 20:247-253.**
16. Nelson RP, Lue TF. Determination of erectile penile volume by ultrasonography. **J Urol 1989;141:1123-1126.**
17. Udelson D, Nehra A, Hatzichristou DG. Engineering analysis of penile hemodynamic and structural-dynamic relationships: part I—clinical implications of penile tissue mechanical properties. **Int J Impot Res 1998;10:15-24.**
18. Shirai M, Nakamura M. Differential diagnosis of organic and functional impotence by the use of 131-I-human serum albumin. **Tohoku J Exp Med 1970;101:317-324.**

19. Kim SC, Kim KB, Oh CH. Diagnostic value of the radioisotope erection penogram for vasculogenic impotence. **J Urol 1990; 144:888-892; discussion 892-893.**
20. Shirai M, Nakamura M, Ishii N, et al. Determination of intrapenial blood volume using 99mTc-labeled autologous red blood cells. **Tohoku J Exp Med 1976;120:377-383.**
21. Zuckier LS, Korupolu GR, Gladshteyn M. A nonimaging scintillation probe to measure penile hemodynamics. **J Nucl Med 1995;36:2345-2351.**
22. Schwartz AN, Graham MM. Combined technetium radioisotope penile plethysmography and xenon washout: a technique for evaluating corpora cavernosal inflow and outflow during early tumescence. **J Nucl Med 1991;32:404-410.**
23. Knoll LD, Abrams JH. Application of nocturnal electrobioimpedance volumetric assessment: a feasibility study in men without erectile dysfunction. **J Urol 1999;161:1137-1140.**
24. Knoll LD, Abrams JH. Nocturnal electrobioimpedance volumetric assessment of patients with erectile dysfunction. **Urology 1999;53:1200-1204.**
25. Margolin EJ, Mlynarczyk CM, Mulhall JP, et al. Three-dimensional photography for quantitative assessment of penile volume-loss deformities in Peyronie's disease. **J Sex Med 2017; 14:829-833.**
26. Johannes CB, Araujo AB, Feldman HA. Incidence of erectile dysfunction in men 40 to 69 years old: Longitudinal results from the Massachusetts Male Aging Study. **J Urol 2000; 163:460-463.**
27. NIH Consensus Conference. Impotence. NIH Consensus Development Panel on Impotence. **JAMA 1993;270:83-90.**
28. Osterberg EC, Maganty A, Ramasamy R, et al. Pharmacologically induced erect penile length and stretched penile length are both good predictors of post-inflatable prosthesis penile length. **Int J Impot Res 2014;26:128-131.**
29. Deveci S, Martin D, Parker M, et al. Penile length alterations following penile prosthesis surgery. **Eur Urol 2006;51:1128-1131.**
30. Wang R, Howard GE, Hoang A, et al. Prospective and long-term evaluation of erect penile length obtained with inflatable penile prosthesis to that induced by intracavernosal injection. **Asian J Androl 2009;11:411-415.**
31. Lee KC, Brock GB. Strategies for maintaining penile size following penile implant. **Transl Androl Urol 2013;2:67-73.**
32. Rolle L, Ceruti C, Timpano M, et al. A new, innovative, lengthening surgical procedure for Peyronie's disease by penile prosthesis implantation with double dorsal-ventral patch graft: the "sliding technique". **J Sex Med 2012; 9:2389-2395.**
33. Egydio PH, Kuehhas FE. Penile lengthening and widening without grafting according to a modified 'sliding' technique. **BJU Int 2015;116:965-972.**
34. Sansalone S, Garaffa G, Djinovic R, et al. Simultaneous penile lengthening and penile prosthesis implantation in patients with Peyronie's disease, refractory erectile dysfunction, and severe penile shortening. **J Sex Med 2012;9:316-321.**
35. Weinberg AC, Pagano MJ, Deibert CM. Sub-coronal inflatable penile prosthesis placement with modified no-touch technique: a step-by-step approach with outcomes. **J Sex Med 2016;13:270-276.**
36. Gaffney CD, Pagano MJ, Weinberg AC. Lengthening strategies for Peyronie's disease. **Transl Androl Urol 2016;5:351-362.**
37. Tran H, Goldfarb R, Ackerman A, et al. Penile lengthening, girth, and size preservation at the time of penile prosthesis insertion. **Sex Med Rev 2017;5:403-412.**
38. Langston JP, Carson CC. Peyronie disease: plication or grafting. **Urol Clin North Am 2011;38:207-216.**
39. Nelson C, Diblasio C, Kendirci M, et al. The chronicity of depression and distress in men with Peyronie's disease. **J Sex Med 2008;5:185-190.**
40. Levine LA. Peyronie's disease and erectile dysfunction: current understanding and future direction. **Ind J Urol 2010;22:246-250.**
41. Chitale S, Morsey M, Sethia K. Is penile shortening part of natural history of Peyronie's disease? **Open Urol Nephr J 2010;3:16-20.**
42. Kadioglu A, Akman T, Sanli O, et al. Surgical treatment of Peyronie's disease: a critical analysis. **Eur Urol 2006; 50:235-248.**
43. Kadioglu A, Kucukdurmaz F, Sanli O. Current status of the surgical management of Peyronie's disease. **Nat Rev Urol 2011;8:95-106.**
44. Ralph DJ, Gonzalez-Cadvid N, Mirone V, et al. The management of Peyronie's disease: evidence-based 2010 guidelines. **J Sex Med 2010;7:2359-2374.**
45. Greenfield JM, Lucas S, Levine LA. Factors affecting the loss of length associated with tunical albuginea plication for correction of penile curvature. **J Urol 2006;175:238-241.**
46. Andrews HO, Al-Akraa M, Pryor JP, et al. The Nesbit operation for Peyronie's disease: an analysis of the failures. **BJU Int 2001;87:658.**
47. Licht MR, Lewis RW. Modified Nesbit procedure for the treatment of Peyronie's disease: a comparative outcome analysis. **J Urol 1997;158:460-463.**
48. Gelbard MK, Hayden B. Expanding contractures of the tunica albuginea due to Peyronie's disease with temporalis fascia free grafts. **J Urol 1991;145:772-776.**
49. Kendirci M, Hellstrom WJ. Critical analysis of surgery for Peyronie's disease. **Curr Opin Urol 2004;14:381-388.**
50. Kadioglu A, Sanli O, Akman T, et al. Graft materials in Peyronie's disease surgery: a comprehensive review. **J Sex Med 2007;4:581-595.**
51. El-Sakka AI, Rashwan HM, Lue TF. Venous patch graft for Peyronie's disease. Part II: outcome analysis. **J Urol 1998; 160:2050-2053.**
52. Kalsi J, Minhas S, Christopher N, et al. The results of plaque incision and venous grafting (Lue procedure) to correct the penile deformity of Peyronie's disease. **BJU Int 2005; 95:1029-1033.**

53. Montorsi F, Salonia A, Tommaso M, et al. Evidence bases assessment of long-term results of plaque incision and vein grafting for Peyronie's disease. **J Urol 2000;163:1704-1708.**
54. Yurkanin JP, Dean R, Wessells H. Effect of incision and saphenous vein grafting for Peyronie's disease on penile length and sexual satisfaction. **J Urol 2001;166:1769-1772.**
55. Levine LA, Dimitriou RJ. A surgical algorithm for penile prosthesis placement in men with erectile failure and Peyronie's disease. **Int J Impot Res 2000;12:147-151.**
56. Wilson SK, Delk JR II. A new treatment for Peyronie's disease: modeling the penis over an inflatable penile prosthesis. **J Urol 1994;152:1121-1123.**
57. Rahman NU, Carrion RE, Bochinski D, et al. Combined penile plication surgery and insertion of penile prosthesis for severe penile curvature and erectile dysfunction. **J Urol 2004; 171:2346-2349.**
58. American Cancer Society. Statistics reports on prostate cancer. Available at: https://www.cancer.org/cancer/prostate-cancer/about/key-statistics.html. Accessed August 25, 2017.
59. Parekh A, Chen MH, Hoffman KE, et al. Reduced penile size and treatment regret in men with recurrent prostate cancer after surgery, radiotherapy plus androgen deprivation, or radiotherapy alone. **Urology 2013;8:130-134.**
60. Munding MD, Wessells HB, Dalkin BL. Pilot study of changes in stretched penile length 3 months after radical retropubic prostatectomy. **Urology 2001;58:567-569.**
61. Fraiman MC, Lepor H, McCullough AR. Changes in penile morphometrics in men with erectile dysfunction after nerve-sparing radical retropubic prostatectomy. **Mol Urol 1999; 3:109-115.**
62. Savoie M, Kim SS, Soloway MS. A prospective study measuring penile length in men treated with radical prostatectomy for prostate cancer. **J Urol 2003;169:1462-1464.**
63. Engel JD, Sutherland DE, Williams SB, et al. Changes in penile length after robot-assisted laparoscopic radical prostatectomy. **J Endourol 2011;25:65-69.**
64. Costello AJ, Brooks M, Cole OJ. Anatomical studies of the neurovascular bundle and cavernosal nerves. **BJU Int 2004; 94:1071-1076.**
65. McCullough AR. Penile change following radical prostatectomy: size, smooth muscle atrophy, and curve. **Curr Urol Rep 2008;9:492-499.**
66. Gontero P, Galzerano M, Bartoletti R. New insights into the pathogenesis of penile shortening after radical prostatectomy and the role of postoperative sexual function. **J Urol 2007; 178:602-607.**
67. Carlsson S, Nilsson AE, Johansson E, et al. Self-perceived penile shortening after radical prostatectomy. **Int J Impot Res 2012;24:179-184.**
68. Briganti A, Fabbri F, Salonia A, et al. Preserved postoperative penile size correlates well with maintained erectile function after bilateral nerve-sparing radical retropubic prostatectomy. **Eur Urol 2007;52:702-707.**
69. Moreland RB. Is there a role of hypoxemia in penile fibrosis: a viewpoint presented to the Society for the Study of Impotence. **Int J Impot Res 1998;10:113-120.**
70. Klein LT, Miller MI, Buttyan R, et al. Apoptosis in the rat penis after penile denervation. **J Urol 1997;158:626-630.**
71. Mulhall JP, Anderson MS, Lubrano T, et al. Peyronie's disease cell culture models: phenotypic, genotypic, and functional analyses. **Int J Impot Res 2002;14:397-405.**
72. Iacono F, Giannella R, Somma P, et al. Histological alterations in cavernous tissue after radical prostatectomy. **J Urol 2005; 173:1673-1676.**
73. Mulhall JP. Penile length changes after radical prostatectomy. **BJU Int 2005;96:472-474.**
74. Hall SJ, Basile G, Bertero EB, et al. Extensive corporeal fibrosis after penile irradiation. **J Urol 1995;153:372-377.**
75. Ajmani M, Jain S, Saxena S. Anthropometric study of male external genitalia of 320 healthy Nigerian adults. **Anthropol Anz 1985;43:179-186.**
76. Ponchietti R, Mondaini N, Bonafè M, Di Loro F, Biscioni S, Masieri L. Penile length and circumference: a study on 3,300 young Italian males. **Eur Urol 2001;39:183-186.**
77. Schneider T, Sperling H, Lümmen G, Syllwasschy J, Rübben H. Does penile size in younger men cause problems in condom use? A prospective measurement of penile dimensions in 111 young and 32 older men. **Urology 2001; 57:314-318.**
78. Sengezer M, Öztürk S, Devecl M. Accurate method for determining functional penile length in Turkish young men. **Ann Plast Surg 2002;48:381-385.**
79. Awwad Z, Abu-Hijleh M, Basri S, Shegam N, Murshidi M, Ajlouni K. Penile measurements in normal adult Jordanians and in patients with erectile dysfunction. **Int J Impot Res 2004;17:191-195.**
80. Söylemez H, Atar M, Sancaktutar A, Penbegül N, Bozkurt Y, Önem K. Relationship between penile size and somatometric parameters in 2276 healthy young men. **Int J Impot Res 2011;24:126-129.**
81. Paez A, Mejias J, Vallejo J, Romero I, De CM, Gimeno F. Long-term patient satisfaction after surgical correction of penile curvature via tunical plication. **Int Braz J Urol 2007;33:502-507.**
82. Taylor FL, Levine LA. Surgical correction of Peyronie's disease via tunica albuginea plication or partial plaque excision with pericardial graft: long-term follow up. **J Sex Med 2008; 5:2221-2228.**
83. Syel AH, Abbasi Z, Hargreave TB. Nesbit procedure for disabling Peyronie's curvature: a median follow-up of 84 months. **Urology 2003;61:999-1003.**
84. Daitch JA, Angermeier KW, Montague DK. Modified corporoplasty for penile curvature: long-term results and patient satisfaction. **J Urol 1999;162:2006-2009.**
85. Rehman J, Benet A, Minsky LS, Melman A. Results of surgical treatment for abnormal penile curvature: Peyronie's disease and congenital deviation by modified Nesbit plication (tunical shaving and plication). **J Urol 1997;157:1288-1291.**

86. Gholami SS, Lue TF. Correction of penile curvature using the 16-dot plication technique: a review of 132 patients. **J Urol 2002;167:2066-2069**.
87. Dugi DDI, Morey AF. Penoscrotal placation as a uniform approach to reconstruction of penile curvature. **BJU Int 2010; 105:1440-1444**.
88. Ding S, Lu J, Zhang H, Wei L, Ding K. A novel modification of tunical plication by plaque thinning: long-term results in treating penile curvature of Peyronie's disease. **Int Urol Nephrol 2010;42:597-602**.
89. Chung E, Clendinning E, Lessard L, Brock G. Five-year follow up of Peyronie's graft surgery: outcomes and patient satisfaction. **J Sex Med 2010;8:594-600**.
90. Levine LA, Estrada CR. Human cadaveric pericardial graft for the surgical correction of Peyronie's disease. **J Urol 2003; 170:2359-2362**.
91. Simonato A, Gregori A, Varca V, et al. Penile dermal flap in patients with Peyronie's disease: long-term results. **J Urol 2010;183:1065-1068**.
92. Horstmann M, Kwol M, Amend B, Hennenlotter J, Stenzl A. A self-reported long-term follow-up of patients operated with either shortening techniques or a TachoSil grafting procedure. **Asian J Androl 2011;13:326-331**.
93. Cormio L, Zucchi A, Lorusso F, et al. Surgical treatment of Peyronie's disease by plaque incision and grafting with buccal mucosa. **Eur Urol 2009;55:1469-1475**.
94. El-Sakka AI, Rashawn HM, Lue TF. Venous patch graft for Peyronie's disease. Part II: outcome analysis. **J Urol 1998; 160:2050-2053**.
95. Craatz S, Spanel-Borowski K, Begemann JF, Olianas R, Fisch M, Hohenfellner R. The dorsal lamina of the rectus sheath: a suitable grafting material for the penile tunica albuginea in Peyronie's disease? **BJU Int 2006;97:134-137**.
96. O'Donnell PD. Results of surgical management of Peyronie's disease. **J Urol 1992;148:1184-1187**.
97. Goyal NK, Kumar A, Das SK, et al. Experience with plaque excision and dermal grafting in the surgical treatment of Peyronie's disease. **Singapore Med J 2008;49:805-808**.
98. Knoll LD. Use of small intestinal submucosa graft for the surgical management of Peyronie's disease. **J Urol 2007; 178:2474-2478**.
99. Levine LA, Benson J, Hoover C. Inflatable penile prosthesis placement in men with Peyronie's Disease and drug-resistant erectile dysfunction: a single-center study. **J Sex Med 2010; 7:3775-3783**.
100. Austoni E, Colombo F, Romano AL, Guarneri A, Kartalas GI, Cazzaniga A. Soft prosthesis implant and relaxing albugineal incision with saphenous grafting for surgical therapy of Peyronie's disease: a 5-year experience and long-term follow-up on 145 operated patients. **Eur Urol 2005;47:223-229**.
101. Grasso M, Lania C, Fortuna F, Blanco S, Piacentini I. Preservation of cavernosal erectile function after soft penile prosthesis implant in Peyronie's disease: long-term followup. **Advances in Urology 2008;8:646-652**.
102. Shaeer O. Trans-corporal incision of Peyronie's plaques. **J Sex Med 2011;8:589-593**.