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CANCER-ASSOCIATED VOIDING DYSFUNCTION (S ELLIOTT AND J PARISER, SECTION EDITORS)

Post-Prostatectomy Incontinence: an Update on Current Management

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Abstract
Purpose of Review To review the most recent literature on the treatment of post-prostatectomy incontinence.
Recent Findings New technology and implementation of surgical devices have resulted in a myriad of treatment options for men suffering post-prostatectomy incontinence. However, many of these have widely varied results.
Summary The treatment of post-prostatectomy incontinence is consistent and continues to expand with more devices being introduced in the market. However, optimization of patient outcomes and determination of which devices work best will be required. To date, there are few randomized controlled trials for the treatment of post-prostatectomy incontinence.

Keywords Post-prostatectomy incontinence · Stress incontinence · Male sling · Artificial sphincter

Introduction and Background

The management of urinary incontinence after radical prostatectomy can be one of the most challenging areas in urology, both for patients and medical practitioners. Given incontinence rates of 4–31% after robotic-assisted laparoscopic prostatectomy (RALP) and 7–40% after radical retropubic prostatectomy (RRP), any urologic provider who cares for men after prostatectomy is bound to encounter a significant population of these patients with post-prostatectomy incontinence (PPI) [1, 2]. The definition of "cure" for incontinence varies both between research studies as well as patients. One patient may be content with a safety pad, while another may find the same level of incontinence extremely detrimental to his quality of life. This underlies the need for informed discussions with patients about treatment options and expected outcomes, both before prostatectomy and before treatment for PPI.

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Predictive Factors of Incontinence and Severity of Incontinence

Comorbid Conditions

The identification of predictive factors for post-prostatectomy incontinence allows for appropriate counseling of patients and management of postoperative quality of life expectations. Obesity increases the risk of PPI at both 12 and 24 months postoperatively in patients undergoing RALP [3], though obese patients who are physically active tend to have better continence outcomes than those who are inactive [4]. Age and preoperative lower urinary tract symptoms (assessed with International Prostate Symptom Score and Overactive Bladder Symptom Score) are also associated with higher rates of PPI [5, 6]. Beyond urinary symptoms, depression and anxiety can have a significant impact on likelihood of incontinence [7].

Imaging

Recent studies have examined the use of MRI to assess preoperative membranous urethral length (MUL) as a predictor of

likelihood of incontinence postoperatively. Though specific cutoff values for MUL vary between studies, increased MUL seems to correlate with increased continence rates [8, 9]. MRI can also be used to estimate the residual MUL after prostatectomy [10]. The use of MUL in preoperative counseling may increase in the coming years as preoperative prostate MRI becomes more common in the era of fusion prostate biopsy.

Surgical Technique

As with any surgery, frequent analysis of surgical technique and impact on outcomes is required in order to provide the best possible patient care. Several recent studies have looked at different aspects of radical prostatectomy and its impact on PPI. Retzius-sparing techniques performed during RALP are similar to perineal prostatectomy with respect to preservation of the space of Retzius. This helps to preserve the anterior attachments of the bladder, maintaining a more anatomic angle postoperatively. Early continence appears to be the largest clinical advantage of this technique, with one study showing 70% of patients completely dry at 1 month and 92% with no pad usage at this time frame [11]. There may, however, be similar rates of continence at 1 year postoperatively when comparing anterior and posterior approaches [12•].

Bladder neck preservation (BNP) has also been proposed as a technique alteration to improve continence rates. This technique aims to preserve muscle fibers at the bladder neck that are thought to be integral to the sphincter complex. Studies have varied as to whether BNP improves both short-term (3 and 6 months postoperatively) and long-term (12 months) continence rates, though a recent meta-analysis showed significant improvements at both time frames [13]. This may come with the risk of increased rates of positive margins, especially at the base of the prostate [14].

Conservative Management

Conservative management of PPI includes behavioral modifications, bladder training, pelvic floor muscle training (PFMT) with or without biofeedback, and electrical stimulation. The European Association of Urology (EAU) recommends timed voiding, reduction of fluid intake, and reduction of bladder irritants such as coffee and spicy food [15]. There is some evidence that bladder training, or systematically increasing the interval between voids, is effective in reducing episodes of incontinence in adults; however, there are no randomized trials evaluating it in the post-radical prostatectomy (RP) population [16]. A Cochrane review also evaluated the efficacy of prompted voiding in elderly men and women, and found limited evidence which did suggest decreased incontinent episodes in the short term [17].

PFMT is nearly universally recommended after radical prostatectomy to both prevent and treat stress urinary incontinence; though there are studies which suggest minimal to no benefit [18]. Nonetheless, the cumulative data do suggest benefit to PFMT and thus it is recommended by the EAU. Numerous trials are included in Table 1. There is no consensus on when to start PFMT, and some studies indicate that preoperative PFMT is beneficial [19–21]. In particular, Burgio et al. demonstrated a statistically significant improvement in the patient-centered outcomes of reduction of incontinence associated with coughing, sneezing, and getting up from lying down [19]. Other data indicate that there is no benefit to beginning PFMT preoperatively [22–24]. Two meta-analyses have evaluated this issue and found conflicting results. Wu et al. detected no difference in continence rates with preoperative PFMT over a standard postoperative regimen [25]; however, Chang et al. found a benefit at 3 months, suggesting it may aid in recovery of continence [26•]. Fortunately, it does appear that there is benefit to PFMT even in a very delayed fashion. Goode et al. performed a prospective randomized control trial including men with stress urinary incontinence persisting anywhere from 1 to 17 years after RP and demonstrated a 50–59% reduction in episodes of incontinence at 1 year after beginning intervention [27].

Physiologically, incomplete understanding of the mechanisms of continence in men after radical prostatectomy may explain some negative results in studies evaluating PFMT. Bladder neck displacement, which is produced by the puborectal portion of the levator ani muscle, has been evaluated using transperineal ultrasound, and while bladder neck displacement was associated with preoperative continence, there was no significant effect of displacement on continence at 12 months after RP, suggesting it may not play a role in the recovery [28].

One barrier to effective PFMT has always been increasing self-recognition of urethral closure during the PFM contraction. Recent data suggests that transperineal ultrasound may offer enhanced PFMT leading to better outcomes compared with verbal instruction alone [29]. More traditionally, biofeedback is the mechanism to improve the quality of PFMT; however, the data are mixed. Ribeiro et al. demonstrated 96% vs. 75% continence rates at 1 year ($p = 0.028$) for patients who had undergone PFMT plus biofeedback for 3 months vs. standard PFMT [30]; however, other studies have shown no benefit [27, 31, 32]. There is also debate about whether intensive PFMT by a physiotherapist is beneficial. Filocamo et al. performed a randomized-control trial with 300 patients and at 6 months, patients undergoing a structured PFMT program with a physiotherapist had a 95% continence rate as compared with 65% in those receiving informal PFMT instruction ($p < 0.001$) [33]. However, numerous other authors have not detected this advantage and frequently point to a lack of cost-effectiveness on the matter [18, 34–36], and a recent meta-analysis failed to

Table 1 Pelvic floor muscle training, biofeedback, and electrical stimulation

Study	*N*	Pre or postop	Intervention	Results	Conclusion
Bales et al.	100	Preop	PFMT with BF vs. without	6-month continence 94% and 96%	No benefit to preop BF
Burgio et al.	125	Preop	PFMT with BF vs. postop PFMT alone	Significant improvement QoL measures	PFMT + BF beneficial preoperatively
Centemero et al.	118	Preop	PFMT preop + postop vs. postop alone	Continence at 3 months 59.3% vs. 37.3%	Preop PFMT beneficial
Dijkstra-Eshuis et al.	122	Preop	PFMT with BF vs. verbal PFMT recommendation	Continence 77.2% all-comers at 1 year; no difference	No benefit to preop PFMT with BF
Filocamo et al.	300	Postop	Formal PFMT program vs. no PFMT instruction	95% vs. 65% continence ($p < 0.001$)	Formal PFMT instruction is beneficial
Geraerts et al.	180	Preop	Preop PFMT vs. postop PFMT alone	Median time to continence 30 and 31 days ($p = 0.878$)	No added benefit of preop PFMT
Glazener et al.	196	Postop	Therapist-guided PFMT vs. standard verbal instruction	Continence at 1 year 76% vs. 77%	No benefit to one-on-one PFMT training
Goode et al.	208	Postop (out to 17 years)	PFMT vs. PFMT + BF + ES vs. no intervention	50% and 59% reduction in SUI episodes	PFMT is effective but BF and ES are unnecessary
Laurienzo et al.	123	Postop	PFMT vs. PFMT + ES	No differences in ICIQ-SF, IPSS, 1 h pad test	No added advantage for ES over PFMT
Lilli et al.	90	Preop	PFMT + BF vs. PFMT alone	71% vs. 66% continent	No benefit for BF over PMFT alone
Mathewson et al.	53	Postop	Education on PFMT + BF vs. no formal education	No difference in time to continence or urine loss	No benefit to intensive PFMT education
Moore et al. 1999	63	Postop	PFMT vs. PFMT + ES vs. verbal instruction only	No differences in any groups at 3, 4, or 8 months	No benefit to intensive PFMT or ES
Moore et al. 2008	216	Postop	Weekly PFMT + BF vs. supportive telephone call	Continence at 1 60% vs. 64% (not significant)	No benefit to intensive PFMT
Ribeiro et al.	54	Postop	PFMT + BF for 3 months vs. standard PFMT	96% vs. 75% continence at 1 year ($p = 0.028$)	PFMT + BF very beneficial after RP
Tienforti et al.	32	Preop	PFMT + BF preop with formal PFMT postop vs. verbal PFMT instruction postop	63% vs. 0% continent at 6 months, and QoL data improved	Preop PFMT + BF in a structured form is very beneficial
Wille et al.	139	Postop	PFMT vs. PFMT + ES vs. PFMT + BF	No difference at 3 or 12 months	No benefit for BF and ES over standard PFMT
Yamanishi et al.	56	Preop	Preop PFMT for all, then postop PFMT + ES vs. PFMT alone	Time to continence 2.7 months vs. 6.8 months ($p = 0.0006$)	ES allows earlier recovery of continence

PFMT, pelvic floor medical therapy, *BF*, biofeedback, *ES*, electrical stimulation, *QOL*, quality of life

find benefit for a physiotherapist-guided training protocol over home-based training [37].

Electrical stimulation (ES) is also added to PFMT in many protocols based on limited evidence showing a benefit [38]; however, numerous trials have demonstrated no benefit [27, 32, 39•]. ES regimens add visits for the patient (e.g., twice weekly visits for 7 weeks [39•]), and a recent Cochrane review detected increased pain and discomfort in patients treated with electrical stimulation compared with PFMT alone with only a short-term (< 6 months) benefit [40].

Other conservative therapies include progressive resistance training, extracorporeal magnetic innervation, and vibration therapy. The relationship between extensor muscle strength and urinary incontinence requires further exploration; however, Park et al. have demonstrated change in hip extensor muscle strength, and endurance following a 12-week resistance program was predictive of continence status (OR 1.039; p = 0.045). Extracorporeal magnetic innervation has limited data to support its addition to the more accessible PFMT with or without biofeedback regimen; however, there may be some benefit and it appears safe [41]. Tantawy et al. evaluated the effect of whole-body vibration therapy on stress urinary incontinence (SUI) after RP and detected significant differences in favor of vibration therapy with a visual analogue scale, Incontinence Short Form (ICIQ-UI-SF), and 24-hour pad test [42]; however, more data is necessary.

Surgical Management

Periurethral Bulking Agents

Periurethral bulking agents are used to improve urethral coaptation and decrease stress urinary incontinence. Though in theory this minimally invasive option is appealing, success rates are overall relatively low compared with artificial urinary sphincter placement. One recent study with Macroplastique injection found a success rate of 43% at 1 month post-injection and 32% at 6 months. Overall, studies have shown bulking agents have an improvement rate of 14.7–76.5% (most studies in the 30% range), though injection materials (collagen or Macroplastique) and number of injections vary between studies [43]. A review of SEER/Medicare data showed that of men undergoing surgical procedures for PPI, bulking agents were the most common procedure (38% of patients). Sixty percent of these patients underwent at least two injections and 39% went on to receive a sling or artificial urinary sphincter (AUS) [44]. Periurethral bulking comes with the risk of acute urinary retention, as the bladder may not be able to generate adequate pressure to overcome excessive coaptation. This risk ranges from 0 to 16% [43].

Urethral Slings

Urethral slings work by providing support to the urethra by returning the urethral bulb to a more pre-prostatectomy location and may improve urethral coaptation, though the precise mechanism is unknown. Recent evaluation with dynamic MRI suggests lengthening of the distance between the vesicourethral anastomosis and the bulbar urethra may be an important aspect of sling function [45]. Slings seem to be best suited for men with mild-moderate PPI, as success rates decline with increasing preoperative incontinence [46]. Various sling models exist, but they can generally be divided into two categories: fixed or adjustable. As the name suggests, the tension for fixed slings is adjusted during surgical placement and cannot be altered after placement. The tension for adjustable slings can be fine-tuned after the procedure. Fixed slings may lose tension over time, offering a theoretical advantage to their adjustable counterparts. One recent systematic review found objective cure rate between 8.3 and 97% in fixed slings and 17 and 92% in adjustable slings with the most common complication being pain in both types of slings [47]. The second most common complications were urinary retention in fixed slings and infection/explantation in adjustable slings [47]. When given the choice of a sling versus artificial urinary sphincter implantation, one study showed most men chose slings despite their lower cure rates [48]. Fixed slings include the AdVance®/AdVanceXP® (Boston Scientific, Malborough, MA) and Virtue® (Coloplast, Minneapolis, MN). The Argus®/Argus T® (Promedon, Cordoba, Argentina) and ATOMS® (AMI, Feldkirch, Austria) are commercially available adjustable slings.

AdVance®/AdVanceXP® (Boston Scientific (formerly American Medical Systems), Marlborough, MA)

The AdVance® and AdVanceXP® are fixed suburethral transobturator slings. The AdVanceXP® is the updated version of the AdVance® with changes to the mesh as well as anchoring system with the goal of improved stability over time. One prospective study of the AdVance® sling found 90% of patients felt improved at 24 months postoperatively and 80% wore 0–1 pad per day [49]. This study did see a decrease in cure rate over time, consistent with the theoretical possibility of the fixed sling losing tension or effectiveness over time. A 36-month prospective evaluation of the AdVanceXP® found a 66% cure rate (0 pads/24 h and 5 g or less on 24 h pad test) and additional 23.4% improved (reduction of greater than 50% on 24 h pad test) [50].

Virtue® (Coloplast, Minneapolis, MN)

The Virtue® quadratic sling is a four-armed monofilament polypropylene mesh device. Two of the arms are passed in a

transobturator fashion and two in the prepubic. In theory, the four arms of the device improve continence by both urethral compression and relocation of the proximal urethra. The initial clinical trial included a cohort of 98 men with roughly equal proportions of mild, moderate, and severe incontinence preoperatively. Objective success (> 50% improvement in pad weight) was seen in 42% of patients at 12 months, with the same proportion of patients reporting subjective success over the same time period [51]. A second smaller trial was performed with 31 patients and was subsequently examined with a new fixation technique and similar results were seen [51]. A subsequent prospective study of 29 patients found 59% of patients used no pads at 36 months [52]. In contrast, a retrospective review of 32 patients with median follow-up of 55 months found a failure rate of 68% with 22% eventually undergoing sling removal [53].

Argus®/Argus T® (Promedon, Cordoba, Argentina)

The Argus® sling is an adjustable suburethral sling placed retropubically while the updated Argus T® is placed in a transobturator fashion. The device consists of a suburethral thick silicone pad which is connected to silicone columns and washers that allow for adjustment postoperatively. The sling is initially calibrated to a retrograde leak point pressure of 30–40 cmH_2O. With respect to the original Argus®, a retrospective analysis of 101 patients with moderate to severe SUI showed 79.2% of patients were considered dry (20 min pad test 0–1 g) at a mean follow-up of 2.1 years, though sling removal was required in 15.8% of patients due to urethral erosion or infection [54]. A prospective evaluation of the Argus T® (n = 37 patients) showed all 8 patients with mild-moderate SUI were dry and 20 of 28 (71%) of patients with severe SUI were dry at 30-month follow-up [55].

ATOMS® (AMI, Feldkirch, Austria)

The adjustable transobturator male system (ATOMS®) device is an adjustable transobturator sling. Urethral compression is achieved via ventral compression of the urethral via a saline-filled silicone cushion which can be adjusted postoperatively by the addition or removal of saline [56]. A recent systematic review found an overall dry rate of 67% and 90% improvement rate after adjustment was completed. When stratified by severity of incontinence, there was a dry rate of 56% in patients with severe SUI and 72% in mild-moderate SUI [57].

Artificial Urinary Sphincter

AMS 800™

The AMS 800™ (American Medical Systems, Marlborough, MA) is the gold standard treatment for men with post-prostatectomy stress urinary incontinence and is approaching four decades of widespread use. AUS implantation has increased from 11 cases in 1975 to 3762 in 2005 [58], spanning multiple models which have steadily improved upon the design with a general trend toward mechanical simplicity and reliability [59]. There are three components to the AMS 800™: a urinary cuff, a pressure regulating balloon to provide a constant pressure within the hydraulic system, and a control pump to regulate movement of fluid.

The AMS 800™ consistently demonstrates social continence rates of 59–85% [60–63], although revision rates may range up to 36% [64]. A recent review of the AMS 800™ identified an association between younger age and penoscrotal approach with increased explantation and revision [65•]. Mechanical failure rates have decreased significantly since the cuff design was changed to a narrow back in 1987 [66]. Urethral atrophy, erosion, and device infection are other potential complications; however, it does appear that efficacy may be comparable with secondary AUS reimplantation compared with primary implantation [67], though not all studies support this conclusion [61••].

Another aspect contributing to the success of the AMS 800™ is its success in complex patients. While tandem cuff implantation has now been found generally to have a higher rate of complications without improvement in continence [68], it may be a reasonable salvage procedure after urethral atrophy causes failure of an initial AUS [69]. Furthermore, transcorporal placement has been shown to be a successful and safe technique in cases of difficult reimplantation at the more distal urethra [70]. Controversy remains in the AUS durability and reoperation rates in irradiated patients with some studies indicating similar complication rates to standard patients [71] and other studies which suggest an increased erosion rate [72•]. The AUS has demonstrated an ability to salvage prior male sling [73].

Overall there are very limited randomized controlled trials comparing different modalities of managing PPI; however, the male synthetic sling versus artificial urinary sphincter trial for men with urodynamic stress incontinence after prostate surgery (MASTER) trial is currently enrolling patients [74••].

FlowSecure™

In 2006, the FlowSecure™ device (Sphinx Medical, Bellshill, UK) was developed as an alternative artificial urinary sphincter to the AMS 800™. This device includes four components: regulator balloon, stress release balloon, circular occluding urethral cuff, and control pump. More specifically, the pressure regulating balloon is adjustable in the range of 0–80 cm H_2O and can be adjusted by injection or removal of normal saline through the self-sealing port on the control pump. One-piece design obviates need for tubing connection and the stress release balloon helps transmit intra-abdominal pressure to the cuff during times of

stress augmenting the continence mechanism, while the self-sealing port allows for in situ pressure adjustment [75]. The initial study demonstrated a 10-fold reduction in mean daily leakage volume [76]; however, there is a paucity of reproducible data and use of the device remains quite limited.

Zephyr

Another alternative urinary sphincter is the Zephyr ZSI 375 (Zephyr Surgical Implants, Geneva, Switzerland) which was created in 2005 and commercially available in 2009. This unit consists of two components, a circular urethral cuff and a control unit that includes a pressure regulating tank connected to a hydraulic circuit and activation button. Benefits include lack of an abdominal reservoir and therefore reduced risk of bladder injury during implantation as well as an adjustable cuff pressure. The device is implanted using a perineal incision for cuff placement and an inguinal incision for pump and tank placement in the scrotum. Results are mixed and there is limited data on post-RP patients as an isolated cohort. Success rate was reported as 73% after 5 years in a cohort of 45 total patients, 33 of whom had a prostatectomy, with complications including infection in one patient (2.2%), mechanical failure in 3 patients (7%), and urethral erosion in 13% [77]. Other results have been modest with success rates ranging from 15% to 58% [78•, 79], with one study demonstrating an alarming explantation rate of 62% due to device defects, infection, non-resolvable pain, and urethral erosion [78•].

Silimed Periurethral Constrictor

The Silimed Periurethral Constrictor (PUC) (Silimed, Rio de Janeiro, Brazil) is a two-piece design developed in the 1990s which has primarily garnered use and some success in the pediatric population [80]. The device involves a constrictor cuff linked to a hydraulically activated self-sealing valve which allows saline injection to create an adjustable static occlusive cuff pressure, with the main benefit being lack of a pump requiring manipulation for voiding. While some short-term data are promising [81], there is a lack of long-term studies demonstrating efficacy. Lima et al. implanted the device in 56 men with SUI after prostatectomy demonstrating a continence rate of 39% and explantation rate of 41% [82], while another study demonstrated complication rate as high as 78% with a 38% risk of urethral erosion [83•].

ProACT™ (Adjustable Continence Therapy)

The ProACT™ system (Uromedica, USA) is a readjustable treatment option where urethral compression is achieved by two balloons placed bilaterally at the bladder neck, connecting to titanium ports in the scrotum allowing for percutaneous readjustment. An appealing aspect to the ProACT™ system is that the mechanism of continence involves increasing static urethral pressure, avoiding manual dexterity requirements of using the AUS [84]. The most recent study with relatively long-term data revealed a decrease in mean daily urine loss from 293 g to 73 g ($p < 0.001$) [85•], and past studies have demonstrated success rates 66–83% [86–88]. Success rates and complication rates are heavily dependent on surgeon experience [89], and there are data which suggest high rates of complications and revisions, as well as long-term efficacy. Venturino et al. demonstrated revision and explantation rates of 73% and 55%, respectively [90]. Additionally, Lebret et al. demonstrated failure of the ProACT™ system in 83% of patients post-irradiation for prostate cancer and that as many as 88% of patients may require adjustments [91].

Overactive Bladder and Urodynamic Testing

Post-prostatectomy incontinence is primarily a result of stress urinary incontinence, though in clinical practice, elements of bladder dysfunction and overactive bladder may also contribute. One recent study found a 37% rate of de novo overactive bladder after RALP. There was also a significant difference in continence rate (defined as no pads) between the de novo OAB and no OAB groups—8% vs. 80% continence, respectively—though this was only at 3 months postoperatively [92]. Another study found a 19% rate of de novo OAB after open prostatectomy, so this phenomenon appears to be present in both surgical techniques [93]. Another systematic review showed an odds ratio of 2.3 for developing PPI for patients with preoperative detrusor over activity [94]. While it is clear the preponderance of PPI is secondary to stress urinary incontinence, it is becoming more apparent that detrusor over activity and urge incontinence may also play a role in a sizable subset of patients.

Management of OAB symptoms after prostatectomy is essentially unchanged compared with the general patient population. Anticholinergics, β-3 agonists, intravesical onabotulinum A injection, and even posterior tibial nerve stimulation and sacral neuromodulation can all be utilized. Care must be taken with patients who develop OAB-like symptoms further out from surgery, as this could represent urinary retention and overflow incontinence secondary to bladder neck contracture. Careful history-taking and measurement of post-void residual volume can aid in identifying this group of patients.

Radiation Effects on Post-Prostatectomy Incontinence

Many patients choose radiation therapy over surgery for clinically localized prostate cancer out of fear of urinary incontinence; however, the rate is not zero. Liu et al.

looked retrospectively at 1192 patients treated with EBRT with at least 2 years of follow-up and found 4.9% used pads occasionally, 0.6% reported intermittent pad use, and 0.6% required pads regularly. Pre-RT TURP was a risk factor for SUI after RT and having a post-RT TURP increased the risk of incontinence 5-fold [95]. Many patients will require RT after RP for adverse features on pathology or biochemical recurrence. Data from the Netherlands described a 17.6% rate of de novo incontinence in patients treated with salvage RT after RP [96•]. There is debate and ongoing trials comparing adjuvant with early salvage and salvage RT in terms of oncologic outcomes; however, Nyarangi-Dix et al. found no significant difference in continence rates between the three modalities, though there was a significant worsening of long-term continence in all groups ($p < 0.001$) with no sign of diminishing effect [97•]. Salvage prostatectomy is another challenging clinical course, and Memorial Sloan-Kettering has published their series where 23% of patients went on to have an artificial urinary sphincter placed for moderate-severe urinary incontinence [98].

Conclusions

The treatment of PPI is currently limited by a number of factors. Further research is needed to understand the true anatomical cause of SUI following radical prostatectomy. Multiple factors may be in play including direct sphincter injury, direct neurological damage, removal of the bladder neck sphincter, and male "pelvic prolapse." Increased understanding of the causative factors will result in improvement in surgical techniques and prevention of SUI. The current number of products available for the treatment of PPI have widely varied success rates. Unfortunately they exhibit a centralized theme with urethral compression by an artificial sphincter cuff or a combination of compression and repositioning using a sling-like device. It is time we advance the technology and look toward the development of devices with new mechanisms of action. Biological and non-surgical techniques will need to be developed as many of the devices have high surgical revision rates. Finally, PPI needs randomized controlled trials with comparative data between devices to truly determine which patients would benefit from each specific device.

Compliance with Ethical Standards

Conflict of Interest Joshua A. Broghammer is a paid consultant and proctor for Boston Scientific, Marlborough, MA. Charles P. Jones and Jack G. Campbell declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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