

Ayodeji E. Sotimehin, MD

Glickman Urological and Kidney Institute,
Cleveland Clinic, Cleveland, OH

Eiftu Haile, MD

Glickman Urological and Kidney Institute,
Cleveland Clinic, Cleveland, OH

Bradley C. Gill, MD, MS

Glickman Urological and Kidney Institute,
Cleveland Clinic, Cleveland, OH; Associate
Professor, Cleveland Clinic Lerner College of
Medicine of Case Western Reserve University,
Cleveland, OH

Contemporary surgical and procedural management of benign prostatic hyperplasia

ABSTRACT

Interventions for benign prostatic hyperplasia have evolved from transurethral resection of the prostate and simple prostatectomy to a myriad of office-based and operating-room procedures. The contemporary approach involves matching the right procedure to the right patient, choosing on the basis of prostate characteristics, patient preference, and urologist expertise. This review details currently available and guideline-backed surgical and procedural treatments.

KEY POINTS

Symptoms of benign prostate hyperplasia can be related to prostate size or shape, or both. Certain surgeries and procedures are better suited for certain sizes and shapes of prostates.

For patients who prefer an in-office procedure or wish to avoid sexual function-related side effects such as retrograde ejaculation, the minimally invasive surgical procedures are excellent choices.

For patients with a larger prostate, holmium laser enucleation and simple prostatectomy are the definitive options and can provide durable results.

For those who wish to avoid a postoperative catheter, the prostatic urethral lift procedure or a temporarily implanted nitinol device may be a good option.

INTERVENTIONS FOR benign prostatic hyperplasia have advanced in the last 30 to 40 years and now include laser procedures, robotic surgery, and office-based minimally invasive surgeries. Historically, transurethral resection of the prostate was the main endoscopic treatment and is still widely used, but it usually causes adverse effects on sexual function, primarily retrograde ejaculation.

Many of the newer treatments remove prostatic tissue more effectively and cause fewer adverse effects than transurethral resection. For instance, holmium laser enucleation of the prostate and photoselective vaporization of the prostate are approximately as clinically effective as transurethral resection but entail less bleeding risk and shorter hospitalization time, recovery time, and catheterization time. Water vapor thermal therapy and prostatic urethral lift, which are both office-based minimally invasive surgical treatments, can be done without general anesthesia and hospitalization.

This review details the operative indications, efficacy, advantages, disadvantages, and complications of various procedures to treat benign prostatic hyperplasia, including the risks of retrograde ejaculation, erectile dysfunction, and urinary incontinence. It does not cover prostate artery embolization, which is still considered experimental, and medical treatment will be covered in a future review.

TABLE 1
Office-based procedures for benign prostatic hyperplasia, compared with transurethral resection

Treatment	Transurethral resection of the prostate	Prostatic urethral lift procedure	Water vapor thermal therapy	Temporarily inserted nitinol device
Surgery type	Cystoscopic electric excision	Cystoscopic placement of sutures to open the urethra	Cystoscopic application of steam to ablate the prostate	Cystoscopic placement of a temporary urethral stent
Operative setting	Operating room	Office	Office	Office
Anesthesia	General or spinal	Local, sometimes with sedation	Local, sometimes with sedation	Local, sometimes with sedation
Ideal prostate size	≤ 80 cc (sometimes a bit larger)	≤ 80 cc with no median lobe enlargement	≤ 80 cc (sometimes a bit larger)	< 75 cc, with no median lobe enlargement
Contraindications	Anticoagulation Elevated bleeding risk Narrow urethra	Large median lobe High bladder neck Allergy to implant	Fibrotic gland (due to prior procedure for prostatic hyperplasia or radiation)	Large median lobe Larger gland Fibrotic gland
Advantages	Historical gold standard Widely accessible	Preserves sexual function	Preserves sexual function	Preserves sexual function
Postoperative catheter time	1–3 days	None (some cases)	3–7 days	None
Durability	Good	Poor	Good	Unknown
Erectile dysfunction	Uncommon	None	None	None
Unique complications	Electrolyte abnormalities (transurethral resection syndrome)	Expected retreatment Bladder stones	Transient retention from prostate edema	Dislodgement or migration

■ TRANSURETHRAL RESECTION OF THE PROSTATE: THE GOLD STANDARD

During transurethral resection, an electrified wire loop is introduced through a scope to shave away the inner portion of the prostate, expanding the prostatic urethral channel and relieving obstruction. First performed in the 1940s, it is so effective that it remains the gold standard with which other procedures for benign prostatic hyperplasia are compared (Table 1).

This procedure is generally done in the operating room with the patient under general or spinal anesthesia. Patients can be discharged home the day of surgery with a Foley catheter or a few days after surgery without a catheter, depending on surgeon preference and clinical situation. The catheter is typically removed on postoperative day 1 to 3.

Efficacy. Of the available treatments, transurethral resection has the most robust and rigorous long-term data. At least three-fourths of patients report their voiding symptoms as “better” or “much better” afterward and have a lower (ie, improved) International Prostate Symptom Score and American Urological Association Symptom Index.¹ Objectively, maximum urinary flow rate, postvoid residual bladder volume, and other measures of urodynamic function also significantly improve after this surgery, and these improvements have been found to persist up to 12 years.²

Because transurethral resection removes prostatic tissue, the prostate-specific antigen level decreases afterward, and the degree to which it falls depends on both the extent (thoroughness) of resection and the histologic (glandular or stromal) makeup of the tissue removed.

Contraindications. Transurethral resection of the prostate is unsuitable for patients who cannot discontinue anticoagulation for surgery.

Complications. The main complications of transurethral resection include hemorrhage requiring a blood transfusion (occurring in 2% of cases in a meta-analysis),³ stress urinary incontinence or permanent lifelong leakage associated with increased abdominal pressure (0.6% or less), postoperative urinary retention (4.5%–6.8%), need for retreatment (0.5%), temporary postoperative dysuria and urinary urgency (0%–38%), urethral stricture (4.1%), and transurethral resection syndrome, ie, acute dilutional hyponatremia (0.8%).^{3–5}

Transurethral resection syndrome typically presents with neurologic symptoms of confusion, nausea, vomiting, hypertension, vision changes, and bradycardia. The incidence of this complication has drastically fallen since the introduction of bipolar electrodes for the procedure, which enabled the use of iso-osmolar irrigant (normal saline). Additionally, using bipolar electrodes poses a lower risk of hemorrhage, as the technology facilitates better hemostasis.

Regarding sexual dysfunction, retrograde ejaculation is the main risk and occurs in about two-thirds to three-fourths of patients.^{6,7} Some physicians tell their patients to expect it with near certainty. The risk is lower if only parts of the prostate are removed and certain areas are preserved.^{8,9} The effects of transurethral resection on erectile function vary, as some studies show it may improve sexual function, while others have shown it can impair erections if the resection is too extensive and perforates the capsule or extends into or beyond the peripheral zone of the prostate (near the neurovascular bundles that facilitate erection).^{10,11}

Bottom line. Overall, transurethral resection of the prostate has withstood the test of time. Like any surgical procedure, it can have excellent outcomes if done by an experienced surgeon.

■ MINIMALLY INVASIVE SURGICAL TREATMENTS

Minimally invasive treatment options for benign prostatic hyperplasia include the prostatic urethral lift procedure, water vapor thermal therapy, and temporary implantation of a nitinol device (Table 1).

Prostatic urethral lift

The prostatic urethral lift procedure (using the UroLift system) is minimally invasive and unique in that it relieves obstruction by mechanically separating and compressing prostatic tissue instead of ablating or resecting it. Through a cystoscope, stainless steel and nitinol anchors are placed in the prostate and con-

nected by permanent sutures. The implants hold the lateral prostatic lobes apart, similar to how curtain ties keep drapes separated beside a window, creating an open channel in the prostatic urethra.

Advantages. Studies show essentially no new ejaculatory or erectile dysfunction or urinary incontinence after prostatic urethral lift.^{12,13} The implants typically do not encrust or form bladder stones, and they typically epithelialize within 12 months.¹⁴ The implants do not affect the prostate-specific antigen level and are benign unless a known allergy exists.¹²

The primary advantages of this procedure are that it can be performed in the office with local anesthesia, it preserves sexual function, and some patients do not need a catheter after the procedure.¹⁵

Efficacy. In a randomized trial comparing urethral lift vs a sham procedure, at 12 months, men who underwent the real procedure had significant improvements in American Urological Association Symptom Index (decreasing from 22 on a scale of 35 before the procedure, to 11.1 after) and maximum urinary flow rate (a gain of 4.4 mL/sec at 12 months, sustained at 4.0 mL/sec at 60 months).¹⁴ In a head-to-head comparison with transurethral resection of the prostate, the success rate was lower with the lift procedure, and the retreatment rate was higher, 11% vs 6% at 2 years.¹⁶ However, all of the patients who underwent the lift procedure maintained ejaculatory function compared with 34% in the transurethral resection group.¹⁶

Contraindications. Prostates with an enlarged median lobe or prostate volume greater than 80 cc are not well suited for this treatment, which highlights the importance of diagnostic cystourethroscopy and prostate imaging (ultrasonography or cross-sectional imaging) to determine candidacy for the procedure.

Complications are generally temporary and include dysuria (in 25%–53%), hematuria (16%–75%), pelvic pain (3.7%–19.3%), and need for postprocedural catheterization (20%–100%).¹⁷ In addition, malpositioned implants can lead to bladder irritation or growth of bladder stones. Although the growth of stones is rare, they almost always require another surgical procedure to manage.¹⁸

Bottom line. While the prostatic urethral lift procedure is an excellent option to preserve sexual function, its long-term durability is unknown, and the lack of tissue removal will likely lead those who undergo it to ultimately require some form of subsequent treatment.

Water vapor thermal therapy

Water vapor thermal therapy (with the Rezūm system) uses steam to ablate prostatic tissue. Through a

specialized scope, the surgeon inserts a small needle to inject water vapor into the transitional zone (lateral and median lobes) of the prostate in up to 15 different sites for up to 9 seconds each. The steam diffuses throughout the prostatic tissue but does not cross the surgical capsule into the peripheral zone. It induces localized cell death and tissue necrosis. Over the next 4 to 6 weeks, the ablated tissue shrinks, enlarging the prostatic lumen.

Because this treatment ablates tissue, the prostate-specific antigen level decreases once inflammation from the procedure resolves. The initial injection of steam often causes prostatic edema, so an indwelling Foley catheter or intermittent catheterization is required for a few days postoperatively.

Advantages. The primary advantages of water vapor thermal therapy are that it can be performed in the office under local anesthesia, it generally preserves ejaculatory function, and it can be used in prostates with a median lobe.

Efficacy. In a randomized trial,¹⁹ water vapor thermal therapy produced significant improvements in symptoms, maximum flow, and quality of life at 12 months. This persisted to 2 years compared with sham treatment, with a 51% reduction in International Prostate Symptom Scores, 4.2-mL/sec improvement in maximum flow, and 50% improvement in quality-of-life scores. These results did not differ in patients with an enlarged median lobe. Ejaculatory bother scores were 31% better at 1 year, and de novo erectile dysfunction was not observed.¹⁹ However, in another study, 4 (2.9%) of 136 men reported ejaculatory dysfunction, which is less than with transurethral resection but more than with prostatic urethral lift.²⁰

Contraindications. Previous radiation treatment or fibrosis of the prostate (due to a prior procedure for benign prostatic hyperplasia) are relative contraindications for this procedure.

Complications of water vapor thermal therapy include dysuria, hematuria, urinary frequency and urgency, hematospermia, and urinary tract infection.^{19,21} These symptoms are typically mild to moderate and resolve within 3 weeks.

Bottom line. Overall, water vapor thermal therapy is an effective minimally invasive surgical treatment that eliminates hyperplastic tissue, although with a delayed time to effect. It can be easily performed in the office, it usually preserves ejaculatory function, and it achieves durable results in a variety of prostate sizes and configurations.

■ TEMPORARILY IMPLANTED NITINOL DEVICE

The iTind device, a temporarily implanted nitinol device, is a newer minimally invasive surgical treatment and one of a growing number of devices inserted into the prostatic urethra. When placed, the wirelike device springs open like a stent in the prostatic channel. It is left in place for only 5 to 7 days before it is removed in the office. While it is in, the struts of the device compress the urethral wall, induce tissue ischemia, and cause tissue remodeling and erosions or incisions into the prostate at the 12, 5, and 7 o'clock positions, effectively performing a transurethral incision of the prostate and improving urine flow.

Device placement can be done in the office with the patient under local anesthesia. No part of the device is left in place permanently, it does not require a postoperative catheter, and it preserves ejaculatory function.

Efficacy. Several single-arm studies show that this procedure significantly improves maximum urinary flow rate, symptoms, and quality of life at 1 to 2 years.^{22,23} In one study, there was no new sexual dysfunction at 2 years.²⁴

Contraindications. This device has not been studied in prostates larger than 60 cc, and in early studies it did not work well in patients with a large median lobe.²³ Many urologists believe that it is likely best suited for patients with tighter and smaller prostates that impede flow due to an elevated or constricted bladder neck and bladder-prostate junction.

Bottom line. The temporarily implanted nitinol device is a helpful addition to minimally invasive surgical treatments, offering novel advantages such as no postoperative catheterization and no permanent implants. However, long-term data on its durability and efficacy are lacking. Additionally, current indications for the procedure are limited to smaller prostates without enlargement of the median lobe. Time will tell if the induced tissue incisions and remodeling of the prostate are durable, and what role this procedure will have in managing benign prostatic hyperplasia.

■ SURGICAL THERAPIES

Surgical therapies other than transurethral resection include photoselective vaporization, endoscopic laser enucleation, robotic or open simple prostatectomy, and robotically controlled water jet treatment (Table 2).

Photoselective vaporization of the prostate

Photoselective vaporization of the prostate, another transurethral procedure, uses the 532-nm GreenLight laser device to open up the prostatic lumen. The light

TABLE 2
Operating-room-based surgeries other than transurethral resection for benign prostatic hyperplasia

Treatment	Photoselective vaporization of prostate	Holmium laser enucleation of the prostate	Simple prostatectomy	Robotically controlled water jet treatment
Surgery type	Cystoscopic laser vaporization	Cystoscopic laser excision	Abdominal excision	Cystoscopic water jet ablation
Operative setting	Operating room	Operating room	Operating room	Operating room
Anesthesia	General or spinal	General or spinal	General or spinal	General or spinal
Ideal prostate size	≤ 100 cc (sometimes a bit larger)	≤ 250 cc	> 80 cc, with or without concomitant pathology, eg, bladder calculi, diverticula	≤ 150 cc
Contraindications	Prior radiation	(Not available)	Anticoagulation Elevated bleeding risk	Anticoagulation Elevated bleeding risk
Advantages	Excellent hemostasis Small caliber scope	Size-independent Durable results	Done under vision (robotic) Durable results	Preserves sexual function
Postoperative catheter time	1 day	1 day	5–10 days	1–5 days
Durability	Good	Excellent	Excellent	Unknown
Erectile dysfunction	Rare	Uncommon	Uncommon	None
Unique complications	Obstruction from sloughed tissue passage	Bladder injury from morcellator	Risks of surgical incision Risks of intra-abdominal surgery	Unknown

is absorbed by hemoglobin in prostatic cells, which heat up and lyse superficially while coagulating more deeply. As a result, the procedure is well suited for patients who are on therapeutic anticoagulation or are at higher risk of bleeding.

This procedure is typically done in the operating room with general or spinal anesthesia and with a small-caliber cystoscope, commonly as an outpatient or same-day surgery. A Foley catheter is generally left in place for 1 day afterward but can be kept in for longer as clinically indicated. As there is less prostate tissue afterward, the prostate-specific antigen level is expected to fall.

Efficacy. In a study in 139 men, photoselective vaporization of the prostate improved American Urological Association Symptom Index scores by 82%, maximum flow rate by 190%, and quality of life scores by 74%.²⁵ These improvements are durable, as evidenced

by a low (6.8%) retreatment rate at 5 years in another report.²⁶ Complication rates and outcomes did not vary with anticoagulant use or prostate size over 80 cc.²⁷

Direct comparisons with transurethral resection show that photoselective vaporization achieves equivalent outcomes with shorter hospital stays and catheterization time.^{28,29} However, as noted previously, like any surgery or procedure, experience with the procedure is what drives excellent outcomes.

Complications of photoselective vaporization of the prostate are similar to those of transurethral resection, but are milder in some respects because the cystoscope is smaller in diameter. These include urethral stricture (2.8%), bladder neck contracture (4.4%), epididymitis (5%–7%), urinary tract infection (1%–20%), hemorrhage requiring blood transfusion (rare), prostatic capsular perforation (0.2%–1%), and need for

retreatment (1.7%–7%).^{30–32} Transient postoperative dysuria and urinary urgency and frequency are expected during recovery as the coagulated tissue sloughs off and is passed with urination.

Several studies show this procedure either does not affect erectile function or may mildly improve it, while ejaculatory loss should be expected with a complete procedure.^{33,34} However, as with transurethral resection, ejaculatory function can be maintained by removing only parts of the hyperplastic tissue as opposed to complete removal.^{35,36}

Bottom line. In a number of practices, photoselective vaporization of the prostate has replaced transurethral resection of the prostate as the default option in light of its superior efficiency and flexibility.

Anatomical endoscopic enucleation of the prostate using a holmium laser

Anatomical endoscopic enucleation of the prostate is a transurethral scope-based approach. An energy source, typically a laser, is used to incise the prostate to enable the surgeon to use mechanical force and the rigid scope to “peel out” or enucleate the hyperplastic tissue (transitional zone) along the surgical capsule, separating it from the peripheral zone of the prostate. This is like removing the inside of an orange (the prostatic tissue) and leaving the rind (the surgical capsule) intact. Once the prostatic lobes are freed, they are pushed into the bladder and morcellated (cut into smaller pieces) so they can be evacuated. The energy source is also used to maintain hemostasis throughout the procedure.

The oldest and best-studied of these procedures is holmium laser enucleation of the prostate, in which a holmium end-fire laser is the energy source. Holmium laser enucleation is a great advance in the surgical management of benign prostatic hyperplasia but has a steep learning curve, which has slowed its adoption and limited its widespread use. However, this is gradually changing as more urologists are becoming aware of its versatility.

Holmium laser enucleation can be used to treat very large prostates (> 120 cc), larger than is possible with transurethral resection or photosensitive vaporization. It is performed in the operating room with the patient under general or spinal anesthesia as a same-day or overnight-stay procedure. The Foley catheter is generally removed the day after surgery. Prostate tissue is removed, so the prostate-specific antigen level should decrease after the procedure.

Efficacy. In a series of 552 patients,³⁷ holmium laser enucleation of the prostate improved International Prostate Symptom Scores by 75% and maximum flow by 200% at 1 year, with a mean hospital stay of 1.5 days

and average catheterization time of 1.4 days. Results are durable, with a 4.2% retreatment rate at 6 years.³⁸ In a randomized trial, compared with transurethral resection, holmium laser enucleation was associated with a shorter catheterization time (27.6 vs 43.4 hours), briefer hospitalization (53.3 vs 85.8 hours), and smaller drop in hemoglobin (1.3 vs 1.8 g/dL) despite a longer operative time (94.6 vs 73.8 min).³⁹ In a meta-analysis,²⁸ American Urological Association Symptom Index scores and maximum flow remained improved at 7 years with both procedures, again highlighting the effect of surgeon expertise with various procedures.

Complications of holmium laser enucleation of the prostate are similar to those of transurethral resection and photoselective vaporization and include capsular perforation, hemorrhage requiring blood transfusion, transient urinary urgency and dysuria, bladder neck contracture, and urethral stricture, all in low numbers that varied in different reports.^{3,40–42} However, morcellator-related complications are specific to holmium laser enucleation of the prostate and can result in ureteral orifice injury, bladder perforation, and rarely, severe bladder damage that necessitates cystectomy and urinary diversion.^{40,43,44}

Additionally, as the procedure entails mechanical dissection, stress on the urinary sphincter complex can result in transient stress urinary incontinence (in 10.7% in one series, improving with time in all but 0.7%).⁴⁰

Retrograde ejaculation is to be expected after holmium laser enucleation, but not erectile dysfunction.^{6,7}

Bottom line. Holmium laser enucleation of the prostate is a versatile treatment for a wide variety of prostate sizes and offers one of the most thorough removals of hyperplastic tissue available, explaining its excellent durability.

Simple prostatectomy: Robotic or open approach

Historically, for prostates larger than 80 cc, open or laparoscopic robotic simple prostatectomy was the treatment of choice. These procedures involve a surgical incision and opening the prostate either from its anterior surface or through the bladder (after opening the bladder too). The surgeon then peels out the hyperplastic tissue (transitional zone) from within the peripheral zone of the prostate, similar to what is done in holmium laser enucleation of the prostate.

Indications. Simple prostatectomy is an excellent option for patients who have massively enlarged prostates or concomitant bladder diverticula, large bladder stones, or a contraindication to the dorsal lithotomy position.

Compared with transurethral resection or photoselective vaporization, simple prostatectomy has a neg-

ligible retreatment rate, as the prostatic hyperplastic tissue is completely removed.

Advances in robotic surgery have improved visualization of the operative field, reduced blood loss, enabled smaller incisions, shortened hospitalization, and improved recovery. Depending on the approach taken (extraperitoneal, transvesical, or transperitoneal), patients spend 1 to 3 days in the hospital and have a Foley catheter for 5 to 10 days after surgery. The new single-port robotic platform has enabled some surgeons to do prostatectomies as same-day surgeries and remove the catheter 3 days later.⁴⁵

Complications. The overall rates of morbidity and mortality associated with simple prostatectomy have greatly improved over the years. The main complications are retrograde ejaculation, hemorrhage requiring blood transfusion (rare in modern series), stress incontinence (rare), erectile dysfunction, bladder neck contracture, and transient urinary urgency and frequency with urge incontinence, which is seen after many procedures for benign prostatic hyperplasia.^{46–48}

Advantages. Whether performed open or robotically, simple prostatectomy is a definitive and durable treatment. Though holmium laser enucleation of the prostate can offer similar long-term outcomes without an incision, the “top-down” approach to the prostate used in simple prostatectomy does not put mechanical stress on the sphincter complex, and thus, transient stress incontinence is much less common than with holmium laser enucleation.^{49–51}

Robotically controlled water jet treatment

Robotically controlled water jet treatment with the Aquablation system is a new technique that is being more commonly adopted. It uses a robotically controlled high-velocity water jet to clear prostatic tissue (similar to a pressure washer) within a predefined area under real-time guidance with transrectal ultrasonography. The surgeon delineates the area of treatment, preserving the bladder neck, external sphincter, and ejaculatory region of the gland, making this a partial and not a complete treatment.

Advantages. This treatment preserves ejaculation (in 80%–90%), erections, and continence. It is performed with the patient under general or spinal anesthesia, can be done as an overnight-stay or same-day surgery, and can be done in prostate glands of varying sizes. In larger glands, multiple passes or treatment runs may be necessary, but these take only a few minutes each.

Efficacy. In a prospective, single-arm trial in 21 men, robotically controlled water jet treatment improved symptoms and maximum flow.⁵²

Complications. Bleeding after tissue removal presents a challenge and requires surgeons to then use a transurethral resection scope to coagulate bleeding vessels and clear away a residual layer of hypertrophic tissue (similar to a very limited transurethral resection of the prostate) and any stubborn areas the water jet did not eliminate. Using a transurethral resection scope after the water jet treatment has enabled it to become a same-day procedure.

Bottom line. As robotically controlled water jet treatment is a new technique, long-term data are needed to evaluate its durability.

THE RIGHT PROCEDURE FOR THE RIGHT PATIENT

We now have a range of options for treating benign prostatic hyperplasia and can choose among them based on prostate size and configuration, operative setting, expected side effects, and patient preferences and quality-of-life goals:

- For patients who prefer an in-office procedure or wish to avoid adverse effects on sexual function such as retrograde ejaculation, the minimally invasive surgical procedures are excellent choices.
- For patients with a larger prostate, holmium laser enucleation and simple prostatectomy are the definitive options and can provide durable results.
- For those who wish to avoid a postoperative catheter, the prostatic urethral lift procedure or a temporarily implanted nitinol device may be a good option.

Additionally, the consideration of a patient's specific anatomy before choosing a treatment option has led to a greater emphasis on preoperative imaging and endoscopic assessment with cystoscopy.

Bottom line. Most if not all available treatments for benign prostatic hyperplasia can deliver excellent outcomes. But as with any other surgery or procedure, the experience of the urologist with each specific treatment is an important factor for quality results. In the contemporary approach to benign prostatic hyperplasia, urologists must balance their skill with the various techniques with the patient's unique prostate anatomy, preferences, and quality-of-life goals to achieve optimal results for their patients.

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Dr. Gill has disclosed consulting, work as advisor or review panel participant, and research as a co-investigator or site-lead for Boston Scientific and UroVant Sciences. The other authors report no relevant financial relationships which, in the context of their contributions, could be perceived as a potential conflict of interest.

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Address: Ayodeji E. Sotimehin, MD, Glickman Urological and Kidney Institute, Q10-125G, Cleveland Clinic, 9500 Euclid Avenue, Cleveland, OH 44195; sotimea@ccf.org