GreenLight Laser Enucleation of the Prostate (GreenLEP): Initial Experience with a Simplified Technique

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OBJECTIVE To present outcomes of a simplified GreenLight laser enucleation of the prostate (GreenLEP) technique and to inform urologists considering incorporation of enucleation into their practice.

METHODS We reviewed all consecutive GreenLEPs by a single surgeon from 2015 to 2018. Baseline patient characteristics, pre-enucleation prostate volume, enucleated adenoma weight, blood loss, lasering time, and energy utilized were recorded. Primary outcomes were urinary flow rate (uroflow) and postvoid residual. Secondary outcomes included International Prostate Symptom Score (IPSS) and prostate-specific antigen change. Primary and secondary outcomes were measured up to 3 years and compared using Student's *t* test. Adverse event and complication rates were recorded.

RESULTS One hundred and eight patients underwent GreenLEP with mean follow up of 10.2 months. Statistically significant improvements were noted at 3 months in Qmax (237%, P <.01) and Qavg (227%, P <.01), with changes remaining durable through 2 years. Statistically significant improvements were noted at 3 months in International Prostate Symptom Score (−64%, P <.01), postvoid residual (−83%, P <.01), and prostate-specific antigen change (−77%, P <.01). Adverse event and complication rates were comparable to other published enucleation studies. Sexual activity was reported in 36% of patients, all of whom reported retrograde ejaculation. Patients experienced dysuria (6%), stress urinary incontinence (6%), urge urinary incontinence (16%), urethral stricture (6%), bladder perforation (n = 2), prostatic capsular perforation (n = 1), and ureteral injury (n = 1).

CONCLUSION Simplified GreenLEP shows effective and durable results with an acceptable adverse event and complication profile. This technique is optimal for novice enucleators familiar with photoselective vaporization. UROLOGY 131: 250–254, 2019. © 2019 Elsevier Inc.

GreenLight laser enucleation of the prostate (GreenLEP) is a treatment for benign prostatic hyperplasia (BPH) which has gained popularity amongst urologists worldwide. Transurethral resection of the prostate (TURP) is the gold standard therapy for BPH with glands smaller than 80 g, while prostates larger than 80-100 g have been managed with simple prostatectomy or staged TURP. More recently, GreenLight (Boston Scientific, Marlborough, MA). Photoselective Vaporization of the Prostate (PVP) has gained popularity, particularly for patients on anticoagulation, and those wanting to avoid admission. However, studies of PVP outcomes have reported disproportionate improvement in symptom score and flow rate between small and large glands, with higher retreatment rates noted with larger glands.[1,2]

Holmium laser enucleation of the prostate (HoLEP), which has no size limitation and is safe in anticoagulated patients, has been shown to be equivalent to simple prostatectomy and TURP with superior urodynamic relief of obstruction and lower complication rates.[3-6] These results have been shown to be durable over a 10 year study period.[7] Unfortunately, a steep learning curve has limited widespread implementation of HoLEP and other endoscopic prostate enucleation techniques, many of which have been described in the literature.[8] The GreenLEP technique was first described by Gomez Sancha in 2010 using a combination of vaporization and enucleation (also known as photoselective vapoenucleation) and has been shown to be safe, effective, and noninferior to HoLEP.[9-12] Gomez Sancha later adopted an en bloc enucleation—a technique later shown to have a shorter learning curve than HoLEP.[13,14] In contrast to

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HoLEP, GreenLEP has been deemed beneficial for novice enucleators who can alternate between enucleation and vaporization throughout their learning curve.[13] GreenLEP offers the familiarity of the side-fire platform for frequent PVP users. It is of particular interest for larger glands, with a recent study showing superiority of GreenLEP over PVP for glands >80g.[15]

We utilize a simplified lobe-by-lobe GreenLEP approach which maintains the novice enucleator's understanding of spatial relationships and prostatic capsular anatomy. A description and video of this simplified GreenLEP was recently published.[16] This series reviews our initial experience with 108 consecutive patients undergoing this procedure.

PATIENTS AND METHODS

After institutional review board approval, we retrospectively reviewed a prospectively maintained database of all consecutive GreenLEP procedures performed at a single institution by a single surgeon between 2015 and 2018. Demographic and baseline characteristics were collected preoperatively including age, race, BPH medications, medical and surgical history, International Prostate Symptom Score (IPSS), uroflow peak flow rate (Qmax) and average flow rate (Qavg), postvoid residual (PVR), and prostate-specific antigen (PSA) level. Preoperative transrectal ultrasound (TRUS) volumes were recorded. Intraoperative variables measured included total lasering time, total energy used, and estimated blood loss. Postoperative variables included weight of adenoma removed (measured during pathologic examination submitted in formalin) and presence of prostate cancer in morcellated prostate tissue. Perioperative adverse events and complications were recorded. Patients were followed longitudinally with IPSS, uroflow, PVR, and PSA at 3 months, 9 months, then annually thereafter for 3 years.

Patients were offered GreenLEP if they had any one of the following: (1) IPSS ≥15; (2) Qmax ≤15 mL/s; (3) PVR ≥100 cc; (4) acute urinary retention; or (5) desire to discontinue BPH medications.

Exclusion criteria included previous radiation therapy for prostate cancer and minimal lateral lobe adenoma as assessed by the surgeon during intraoperative TRUS. The absence of significant lateral lobe adenoma (isolated median lobe disease) makes engaging and staying in the lateral surgical capsule difficult. These types of prostates were treated with a vapoenucleation technique.

The primary outcomes of this study were change in Qmax and Qavg at 3, 6, 9, 12, and 24 months. Secondary outcomes included change in IPSS and PVR at the same time intervals. PSA was measured preoperatively at 3 months and then annually if normal (<4 ng/mL) as per AUA guidelines. These measurements were compared using Student's *t* test in R (Vienna, Austria; version 3.5.2). $P < .05$ was considered statistically significant.

Surgical Technique

Simplified GreenLEP technique utilizes a 26 Fr Wolf (Richard Wolf, Knittlingen, Germany) cystoscope and 10-2090 GreenLight laser fiber.[16] At 35W coagulation setting the distal extent of the enucleation is marked at the proximal verumontanum. Grooves are then created at the 80W vaporization setting into the adenoma down to the capsule at 5 and 7-o'clock, effectively separating the median lobe from the lateral lobes. The plane between the median lobe and prostatic capsule is developed in a retrograde fashion toward the bladder neck. Using blunt dissection with intermittent coagulation of vessels and fibrous attachments, the median lobe is separated from the capsule and enucleated in a retrograde fashion. Once the median lobe is separated to the bladder neck, the bladder neck attachments are transected laterally to medially. The median lobe is placed inside the bladder for later morcellation.

The distal extent of enucleation is then demarcated anteriorly and laterally and an anterior commissurotomy is created. Enucleation of the lateral lobes is performed 1 lobe at a time. The capsular plane is entered apically and laterally, then anteriorly toward the bladder neck, leaving the posterior attachments intact. This anterolateral dissection is continued until the bladder lumen is entered at 1-3 o'clock for the left lateral lobe and 9-11 o'clock for the right lateral lobe. The anterior attachments are then separated laterally to medially, followed by the posterior attachments as the lateral lobe is rolled into the bladder. This procedure is repeated on the contralateral side.

Once all 3 lobes have been placed inside the bladder and adequate hemostasis is ensured, a Wolf Piranha morcellator is inserted and utilized to morcellate the adenoma. A more detailed description and surgical video have previously been published.[16]

RESULTS

Baseline Characteristics

One hundred and eight patients underwent GreenLEP with mean follow up of 10.3 months (range 0-37). Baseline patient data and operative characteristics are detailed in Table 1. Preenucleation TRUS volumes were 34-166 cc with a mean of 77 cc. Twenty-four percent of patients were on aspirin or clopidogrel preoperatively for prophylaxis, history of atrial fibrillation or cardiac stents and these agents were cleared to be held for surgery by the patients' cardiologists. Eighteen percent of patients underwent prior TURP. All patients had preoperative urine culture which was either negative or treated if positive prior to surgery.

Table 1. Baseline and operative characteristics of the cohort

Baseline Characteristics	
n	108
Age (y)	69 (50-91)
Medications	*n* (%)
α-blockers	68 (63%)
5-α-reductase inhibitors	37 (34%)
Aspirin/plavix	26 (24%)
Coumadin/xarelto	3 (3.7%)
Cialis	15 (14%)
Previous TURP	19 (18%)
Pre-op TRUS (cc)	77 (33-166)
Operative Characteristics	
Laser time (min)	24 ± 7 (49-12)
Energy used (kJ)	77 ± 31 (26-196)
Estimated blood loss (cc)	33 ± 36 (0-200)
Prostate cancer identified (*n*)	18 (17%)
Gleason score (mean)	6 (6-7)

Operative Characteristics

Mean energy spent was 77 kJ with mean lasering time of 24 minutes. Mean estimated blood loss was 52 cc and mean morcellated tissue removed was 44 g (9 g-103 g). Fifteen percent of patients had prostate adenocarcinoma identified from morcellated prostate tissue (3 patients with Gleason 7 and 14 with Gleason 6 disease), comprising a mean of 1.8% of morcellated tissue from those patients. There were no conversions to TURP.

Outcomes

The primary and secondary outcomes at 3-, 9-, 12- and 24-month follow-up are listed in Table 2. Qmax improved from a mean of 9.0 (SD 4.8) to 21.3 (SD 9.7, P <.01) at 3 months, and remained durable through 2 years (P <.01). Similarly, Qavg improved from 4.9 (SD 2.5) to 11.1 (SD 6.2, P <.01) at 3 months, and remained durable through 2 years (P <.01). IPSS score improved from a mean of 17.5 (SD 8.1) to 6.3 (SD 4.9, P <.01). TRUS volume decreased from a mean of 77.3 (SD 29.1) to 36.0 (SD 18.2, P = .03). PVR decreased from a mean of 219.4 (SD 181.8) to 36.8 (SD 38.5, P <.01), and remained decreased through 2 years (P <.01). PSA decreased from a mean of 4.4 (SD 2.7) to 1.0 (SD 1.6, P <.01) and remained decreased through 2 years (P <.01).

Adverse Events

Adverse events are summarized in Table 3. All patients were admitted overnight for observation. All catheters were removed in <24 hours, with 7 patients initially failing, then passing voiding trials within 48 hours. Sexual activity was noted in 36% of men postoperatively, with all reporting retrograde ejaculation. Stress urinary incontinence occurred in 7 patients (6%), all of whom had complete resolution by 1 year. Seventeen patients (16%) experienced urge urinary incontinence, of whom 9 had complete resolution by 1 year. No patients developed bladder neck contracture. Six patients (6%) developed new urethral strictures or meatal stenosis, diagnosed by examination or cystoscopy. These patients were managed with office dilation followed by daily self-dilation over 6 weeks. Three patients had resolution by 1-year follow-up. Dysuria occurred in 7 patients (6%), of whom 5 had resolution.

Complications

The overall complication rate was 4% and included perforation of the prostatic capsule (n = 1; Clavien I), intraperitoneal bladder perforation requiring open repair (n = 1; Clavien IIIb), extraperitoneal bladder perforation (n = 1; Clavien IIIa) and ureteral injury requiring ureteral stent placement (n = 1; Clavien IIIb). The intraperitoneal bladder perforation was the result of an occluded catheter while the patient was on continuous bladder irrigation on the first postoperative day. Subsequent exploration revealed a bladder diverticulum had ruptured and this was repaired primarily. The extraperitoneal bladder perforation was the result of a bladder injury which occurred during morcellation and this was managed with a catheter for 72 hours.

DISCUSSION

As with all endoscopic enucleation techniques, the en bloc GreenLEP technique described by Gomez Sancha et al, is associated with a learning curve which may vary based on surgeon experience. A step-wise approach to learning en bloc enucleation has been suggested, starting

Table 2. Primary and secondary study endpoints at 3, 9, 12 and 24 months

	Baseline	3-Month	9-Month	12-Month	24-Month
Q_{max} (mL/s)	9 ± 4.8 n = 101	21.3 ± 9.7 n = 77 P <.01	21.8 ± 9.0 n = 39 P <.01	26.7 ± 17.2 n = 26 P <.01	22.0 ± 9.7 n = 16 P <.01
Q_{avg} (mL/s)	4.9 ± 2.5 n = 100	10.7 ± 6.2 n = 77 P <.01	10.3 ± 5.2 n = 38 P <.01	13.8 ± 8.1 n = 26 P <.01	9.9 ± 5.0 n = 16 P <.01
Voided volume (mL)	168.3 ± 100.9 n = 101	217.9 ± 128.2 n = 77 P <.01	219.9 ± 124.7 n = 38 P <.01	306.3 ± 110 n = 26 P <.01	240.5 ± 140 n = 16 P = .06
PVR (mL)	219.4 ± 181.8 n = 104	36.8 ± 38.5 n = 84 P <.01	43.4 ± 62.9 n = 46 P <.01	23.4 ± 22.7 n = 30 P <.01	40.6 ± 49.3 n = 18 P <.01
PSA (ng/mL)	4.43 ± 2.7 n = 101	1.0 ± 1.5 n = 74 P <.01	1.1 ± 0.8 n = 21 P <.01	1.0 ± 0.7 n = 20 P <.01	1.1 ± 0.8 n = 17 P <.01
IPSS	17.6 ± 8.1 n = 70	6.23 ± 4.9 n = 27 P <.01	-	-	-
IPSS-QOL	3.6 ± 1.4 n = 70	1.44 ± 1.3 n = 25 P <.01	-	-	-

Table 3. Adverse events and complications

Adverse Events	*n* (%)
Urinary retention	7 (6%)
Retrograde ejaculation	39 (36%)
Stress urinary incontinence	7 (6%)
Urge urinary incontinence	17 (16%)
Urethral stricture/meatal stenosis	6 (6%)
Dysuria	7 (6%)
Complications	
Perforation of prostatic capsule	1 (1%)
Intraperitoneal bladder perforation	1 (1%)
Extraperitoneal bladder perforation	1 (1%)
Ureteral injury	1 (1%)

with vaporization, then moving on to partial enucleation before en bloc enucleation.[13] Mastery of this technique requires a strong spatial understanding of prostatic anatomy in order to enucleate the entire prostate en bloc without losing orientation. This spatial recognition is unfamiliar to many urologists and a lack of comfort with developing the appropriate planes precludes surgeons from attempting enucleation as has been our own experience with training over 50 urologists new to GreenLEP. The variability of prostatic anatomy in men with BPH makes en bloc enucleation even more difficult for the novice enucleated to learn proficiently. The simplified GreenLEP technique is optimized for novices who have not yet mastered the spatial configuration of the prostate and its capsular plane endoscopically. This technique allows the surgeon to deviate from total enucleation and complete the surgery with vaporization (vapoenucleation) should the need arise from unforeseen complexity.

Our series shows that the simplified GreenLEP technique results in a robust improvement in urinary flow rates, IPSS and PVR, and a significant decrease in PSA without deterioration throughout the study period. These rates, along with those of adverse events and complications, were comparable to those cited in the published GreenLEP and HoLEP literature.[9,11,14,17]

Simplified GreenLEP allows for a lobe-by-lobe approach in which the novice enucleator develops a spatial understanding of the prostatic capsule and adenoma, beginning with enucleation of the median lobe. This technique also provides the same surgical outcomes in terms of complete removal of the transition zone adenoma down to the surgical capsule as en bloc GreenLEP and traditional HoLEP. However, during the learning curve, the surgeon may choose to perform lateral lobe vaporization if enucleation is not progressing successfully, such as in the vapoenucleation techniques described previously.[9,10] Surgeons can develop in a step-wise fashion the surgical proficiency that is needed for complete whole gland enucleation. This series of whole gland simplified GreenLEP represents our experience once surgical proficiency was attained.

One of the main advantages of GreenLight compared to holmium lasers for the novice enucleator is that PVP is the laser technique most urologists are accustomed to when it comes to treatment of the prostate.[18,19] The 532 nm side-fire, noncontact laser fiber is familiar to most urologists. Additionally, the GreenLight technology is considered particularly useful because of its hemostatic properties.[19] Enucleation procedures are typically done on larger gland prostates and can have potentially greater bleeding risks. Good hemostasis provides better visualization for these complex procedures allowing for faster learning curves.

Our study does have several limitations. This was a single institution, single surgeon study of a novel surgical technique. Ideally this technique would have been compared to TURP, the gold standard treatment for BPH. However, given we have completely adapted GreenLEP into our practice, TURP is rarely performed at our institution. Furthermore, comparisons between the outcomes of different surgeons at different institutions using different techniques are difficult, with outcomes depending on multiple factors including surgeon experience and differences in patient populations. This represents the first and only report of outcomes with the simplified GreenLEP and therefore direct comparison of other institutions is not yet feasible. Multisurgeon, multicenter randomized controlled trials comparing different enucleation techniques to each other and to TURP are lacking and are needed to truly compare outcomes of these treatment modalities. Unfortunately, only 1 randomized controlled trial has compared GreenLEP to HoLEP.[9] This study is limited by its use of a vapoenucleation technique rather than true enucleation. Our study is also limited by a relatively short mean follow-up period of 10.3 months.

Other perceived limitations of GreenLEP include cost, with reports of substantial differences between fiber costs for GreenLight compared to holmium, as well as the occasional need for simultaneous use of holmium laser for management of lower tract urolithiasis.[20] In our series, only 1 patient had a bladder stone which required holmium laser lithotripsy. This is likely a factor of bladder stones being nonendemic in our patient population and the low rate of concomitant stones in BPH patients (roughly 10%).[21] While there is indeed a cost difference between laser fibers, urologists unfamiliar with using end-fire holmium for BPH surgery may be more likely to perform these procedures with a laser fiber they feel most comfortable with.

These limitations notwithstanding, endoscopic prostate enucleation is a safe and effective treatment option in appropriately selected patients. Steep learning curves for the various enucleation techniques remain the most significant hurdle for many urologists in adopting these procedures. It is our belief that by utilizing a more familiar BPH laser platform, GreenLEP is an optimal choice for novice enucleators. Simplified GreenLEP is safe and effective, with acceptable rates of adverse events and complications, and is optimal for urologists interested in learning enucleation. Through increased utilization of enucleation amongst urologists, equipment costs will decrease, costs to payers will be driven down, further research will be

conducted comparing various techniques, and patients will have increased access to optimal management of their BPH-associated lower urinary tract symptoms (LUTS).

CONCLUSION

Simplified GreenLEP shows effective and durable results, with acceptable rates of adverse events and complications. GreenLEP is an optimal technique for urologists interested in learning endoscopic prostate enucleation who are familiar with the GreenLight PVP platform. Increased utilization of GreenLEP and other enucleation procedures might improve the quality of care for BPH patients. Prospective studies comparing simplified GreenLEP to TURP and other enucleation techniques are needed.

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