GreenLight laser prostatectomy: Are outcomes sustainable after a decade of surgery?

A single-center experience with up to 15 years' followup

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ABSTRACT

INTRODUCTION: Herein, we report our single-center experience with long-term outcomes over a period of 15 years.

METHODS: Between 2005 and 2020, a prospectively maintained database for patients undergoing GreenLight photoselective vaporization of the prostate (PVP) for symptomatic benign prostatic hyperplasia (BPH) was reviewed. Three generations of GreenLight laser were used over this period. Patients with ≥10 years of followup were included. Demographic and perioperative data were collected, including International Prostate Symptom Score (IPSS), quality of life (QoL), peak flow rate (Qmax), postvoid residual urine (PVR), and prostate-specific antigen (PSA) changes. Perioperative and late adverse events were also recorded.

RESULTS: A total of 712 patients with a mean age of 73.9±7.8 years were included in the study, with a median followup of 12.1 years and a mean preoperative prostate size of 72.4±15.3 mL. There were significant reductions in mean IPSS, QoL, and PVR (60.4%, 65%, and 72.6%, respectively; all $p<0.001$) at the most recent followup compared to baseline values. Likewise, a significant improvement in Qmax (8.2 to 17.7 ml/sec, $p<0.001$) and a PSA reduction of 64.2% were noted at the most recent followup. The blood transfusion rate was 1.5 %. Transient postoperative dysuria was encountered in 44 (6.2%) patients. Development of bladder neck contracture and urethral stricture were encountered in 18 (2.5%) and 15 (2.1%) patients, respectively. Twenty-four (3.37%) patients required repeat surgery for adenoma regrowth.

CONCLUSIONS: Our long-term functional outcomes support the durability of the GreenLight laser PVP, with acceptable long-term adverse events after a decade of surgery.

INTRODUCTION

Benign prostatic hyperplasia (BPH) is a common condition that can cause bladder outlet obstruction (BOO) and bothersome lower urinary tract symptoms (LUTS) in men.[1] In a recent population-based study, 50% of men develop moderate to severe LUTS by their eighth decade of life, causing a negative impact on quality of life by affecting sleep quality and daily activities.[2,3]

For a long time, transurethral resection of the prostate (TURP) was considered the gold standard treatment for BPH.[4] In the mid-1990s, the urologic community witnessed the advent of several new laser therapies, including the GreenLight and holmium-YAG lasers for surgical management of BPH.[5] Each laser technology is characterized by its specific light wavelength and physical properties. Since its introduction in 2005, GreenLight laser has been widely adopted as a convenient source of energy for the surgical treatment of BPH.[6]

While several studies demonstrated the feasibility and safety of the GreenLight photoselective vaporization of the prostate (PVP), few have assessed the durability of the PVP technique over long-term followup (>10 years).[7-9] The Global GreenLight Group recently conducted a large-scale study in which they used a multicenter, international database of patients undergoing PVP with a median followup of six months to demonstrate the safety

and effectiveness of PVP surgery in experienced hands.[8] Furthermore, Ajib et al demonstrated the durability, efficacy, and safety of the GreenLight PVP over a five-year period;[9] however, there is paucity in the literature quantifying long-term outcomes (>10 years) of GreenLight PVP.

The aim of the current study was to present our experience regarding long-term surgical outcomes, complications rate, and durability of GreenLight PVP over a 15-year period.

METHODS

Study design

A prospectively collected database of patients undergoing GreenLight Laser PVP for symptomatic BPH with data collected from 2005–2020 was reviewed. All cases were performed or supervised by two expert surgeons at a tertiary care center.

Data collection and perioperative workup

Data collected pertaining to demographics and perioperative period included patients' age at surgery, comorbidities, use of medications for BPH or anticoagulation, previous history of prostatic surgery, early and late postoperative complications, total operative time, American Society of Anaesthesiologists (ASA) score, International Prostate Symptom Score (IPSS), including quality of life (QoL), peak flow rate (Qmax), postvoid residual urine volume (PVR), and prostate-specific antigen (PSA) levels. Patients were followed at one, three, six, and 12 months, and then annually up to 15 years. Postoperative PSA reduction was used as an indicator for efficient vaporization of prostatic tissue.

The subtotal voiding and storage symptom scores of the IPSS, including urgency, frequency, and nocturia symptom scores, were collected and compared at baseline and at followup visits. Moderate or severe storage symptoms were defined as IPSS storage score ≥9.

Surgical technique

The patients were treated using three generations of GreenLight Laser, including KTP/80 W, HPS/120 W, and XPS/180 W laser systems (AMS, Minnetonka, MN, U.S.), over this time period. Procedures were performed by two experienced surgeons at our institution. Techniques were performed as previously described in the literature.[10,11]

Statistical analysis

Data were analyzed with SPSS, version 21. Descriptive statistics are presented as mean and median using frequency and percent points. Fisher's exact test was used to compare categorical variables and Student t-test or the Mann-Whitney U test for normally and abnormally distributed continuous variables, respectively. Two-tailed $p<0.05$ was considered statistically significant.

RESULTS

After exclusion of patients with missed followup data, a total of 712 patients with a mean age of 73.9 (range 54–85) years were included in our cohort, with a median followup of 12.1 years. Of those, 26% presented with indwelling urethral catheters at the time of surgery, and 95% received medications for LUTS. Mean preoperative prostate size detected on transrectal ultrasound (TRUS) was 72.4±15.3 mL, and mean baseline PSA was 5.3±4.2 ng/mL. Demographic and perioperative data are presented in Table 1.

Adverse events

With regard to perioperative complications, blood transfusions were required in 11 patients (1.5%). All of them were on anticoagulation therapies and resumed their anticoagulation on the day of surgery. Additionally, 46 (6.5%) patients experienced a failed trial of void (TOV) after surgery but eventually voided; 44 patients (6.2%) had persistent dysuria, which resolved by three months after surgery, and 12 patients (1.7%) developed postoperative epididymo-orchitis (Table 1).

Regarding long-term adverse events, persistent LUTS were encountered in 15 patients (2.1%), repeat surgery for adenoma regrowth in 24 patients (3.3%), stress urinary incontinence (SUI) in nine cases (1.2%), bladder neck contracture (BNC) in 18 cases (2.5%), urethral stricture in 15 cases (2.1%), and bladder stone in three cases (0.4%) (Table 1). At long-term followup (>10 years), five patients (0.7%) remained catheter-dependent, and six patients (0.8%) required intermittent catheterization (CIC).

Long-term functional outcomes

After a mean followup of 12.1 (10–15) years, only 124 patients of the cohort exceeded 10 years of followup. There were significant reductions in mean IPSS, QoL, and PVR (percent reductions were 60.4%, 65.0%, and 72.6%, respectively, $p<0.001$) at the most recent followup (Table 2).

Likewise, there was a significant increase in Qmax (8.2 to 17.7 ml/sec, $p<0.001$), with 64.2% PSA reduc-

Table 1. Demographic and perioperative data with long-term complications

Variables		Mean ± SD n (%)
Age at time of surgery (years)		73.9±7.8
Patients with diabetes mellitus		5 (0.7)
Preoperative medications for LUTS		118 (16.6)
Patients with indwelling urethral catheters		32 (4.5)
Preoperative PSA (ng/dl)		5.3±4.2
Preoperative IPSS		19.9±5.5
Preoperative QoL		2.81.5
Preoperative Qmax		8.2±4.2
Preoperative PVR		162± 128
Preoperative prostate size by TRUS		72.4±15.3
Perioperative data	Energy used (KJ)	322.3±132
	Operating time (min)	92.4±41
	Catheterization time (days)	1.1±0.6
	Hospital stay (days)	1.3±0.96
Early postoperative complications	Failed trial of void	46 (6.5)
	Persistent dysuria (>3mths postop)	44 (6.2)
	Epididymo-orchitis	12 (1.7)
Long-term complications	Blood transfusion	11 (1.5)
	Redo for regrowth adenoma	24 (3.3)
	Persistent LUTS	15 (2.1)
	Stress urinary incontinence	9 (1.2)
	Bladder neck contracture	18 (2.5)
	Urethral stricture	15 (2.1)
	Bladder stone	3 (0.4)

IPSS: International Prostate Symptom Score; LUTS: lower urinary tract symptoms; PSA: prostate-specific antigen; PVR: postvoid residual; Qmax: peak flow rate; QoL: quality of life; SD: standard deviation; TRUS: transrectal ultrasound.

tion from baseline (Table 2). The trend of improvement of functional outcomes during different followup visits is presented in Figure 1. Additionally, 20.5% of patients required the resumption of medical therapy (alpha-blockers, β3-agonists, or anticholinergics) during followup, primarily due to the recurrence of LUTS or the development of storage symptoms over time.

The perioperative parameters among the three different GreenLight generations are described in Table 3. Operating time with KTP-80W (51.5 min) and lasing time (45.9 min) were significantly lower than those of others. It is noteworthy that the mean prostate volume (42.0 mL) in those undergoing KTP-80W was also significantly lower. There were no significant differences in terms of catheterization time or hospital stay duration. The XPS-180W laser machine appeared to achieve a more pronounced decline in storage symptoms earlier postoperatively compared to the KTP and HPS machines (Figure 2).

DISCUSSION

Currently, there are several minimally invasive treatment options for the management of symptomatic BPH; the GreenLight 532 nm laser PVP, which is selectively absorbed by hemoglobin, is a safe and feasible treatment option.[12] In fact, GreenLight PVP is a reasonable treatment option for patients with bleeding disorders or on anticoagulation therapies due to its efficient hemostasis and minimal risk of intraoperative bleeding.[12,13] GreenLight PVP is also associated with shorter operative time and a shorter learning curve, which makes it a more feasible and convenient technique compared to other treatment modalities, such as enucleation.[7]

Consequently, recent American Urological Association and European Association of Urology guidelines have recommended the use of GreenLight laser PVP for the treatment of symptomatic BPH ≤80 g.[13,14] While several studies have demonstrated the safety and efficacy of GreenLight laser PVP in the surgical treatment of BPH, to date, there are scant studies that have shown encouraging long-term functional results over five years of followup.[15] The present study presents our institution's long-term experience with GreenLight laser PVP over a period of 15 years.

With regard to functional outcomes, our study revealed significant improvements in IPSS and QoL scores, Qmax, and PVR at early followup visits, and these results were maintained over a median followup of 12.1 years. Likewise, a 65% reduction in PSA values persisted over the entire followup period. These findings confirm the durability of the PVP technique for the treatment of symptomatic BPH over more than a decade after surgery.

Furthermore, the overall rates of perioperative and postoperative complications of GreenLight PVP appear to be quite low, as demonstrated by the results of our study. We found that the rate of blood transfusion was low at 0.4%. This could be attributed to the physics of the GreenLight laser, which is selectively absorbed by hemoglobin, resulting in superior hemostasis. All three patients who required a transfusion in the current study

were instructed to resume their anticoagulation therapy on the day of surgery.

Additionally, 6.5% of patients experienced a failed TOV after surgery. They were managed conservatively and with alpha-blocker medications until they eventually voided within the first month of surgery; only 0.8% of them required repeat surgery for regrowth adenoma.

In addition, 6.2% had persistent dysuria, which lasted for three months after surgery. The mechanism of postoperative dysuria after GreenLight laser PVP could be explained by two main factors. First, the shorter laser wavelength (532 nm) of the GreenLight results in deeper tissue penetration compared to other laser sources, such as the Holmium:YAG laser. Second, the high intraprostatic temperature yielded from the GreenLight laser beam causes coagulative necrosis of prostatic tissue and vaporization. We believe the risk of postoperative dysuria should be discussed with the patient before GreenLight laser PVP surgery.

Moreover, a few long-term complications did occur, such as SUI in 0.3%, BNC in 1.3%, and urethral stricture in 1.0%. Likewise, the reoperation rate in our cohort was also quite low (0.8%). These findings reinforce the safety, sustainability, and durability of the PVP technique in the long term.

The results of our study were consistent with what was found by Batura et al after a two-year followup, namely a 47% reduction from PSA at baseline and a 64% improvement in Qmax. In terms of complications, they noted more strictures (3.4%) and a more frequent reoperation rate (4.3%).[16]

Another single-center experience with 500 procedures reported by Ruszat et al noted similar improvements in functional parameters (108% increase in Qmax, 58% in IPSS score, and 61% in QoL score), but higher incidence rates of bladder neck and urethral strictures (3.6% and 4.4%, respectively) after a mean followup of 30 months using the 80 W laser.[17]

In another large, multicenter, prospective study including 2648 patients with BOO secondary to BPH, those undergoing PVP (18%) had the lowest overall adverse events compared to those undergoing TURP and ThuVep over a three-year followup.[18]

Persistent LUTS and urinary incontinence are also relevant complications worth mentioning, as they negatively impact QoL.[19] In the aforementioned multicenter, prospective study comparing three different surgical modalities (PVP, TURP, and ThuVEP), only 44 patients reported postoperative urinary incontinence of any kind, most of whom were in the PVP group;[18] however, only two of our patients (0.3%) experienced SUI. Persistent LUTS were encountered in 0.8% of our patients. It appears that voiding symptoms early after surgery improve more drastically following PVP than storage symptoms owing to the irritative effect of the laser beam applied to the adenomatous tissue;[20] however, this might be beneficial in terms of hemostasis, as blood transfusions were rarely required even in patients who were anticoagulated. Our data aligns with previous studies.[21,22]

It is imperative to recognize that different GreenLight laser generations (80 W KTP, 120 W HPS, and 180 W XPS) possess varying power outputs and tissue ablation capabilities. The 80 W KTP laser (first generation) was relatively less powerful and slower at vapor-

Table 2. Long-term functional outcome after 10–15 years followup (n=124)

Variable	Baseline mean ± SD	Most recent followup mean ± SD	% change	p
PSA (ng/ml)	5.7±4.8	2.0±1.6	64.9	<0.001
IPSS	19.9±5.5	7.8±3.4	60.8	<0.001
QoL	2.8±1.5	1.1±1.2	60.7	<0.001
Qmax (mL/sec)	8.2±4.2	17.7±10.4	115.9	<0.001
PVR (mL)	162±128	44±52	72.8	<0.001

IPSS: International Prostate Symptom Score; PSA: prostate-specific antigen; PVR: postvoid residual; Qmax: peak flow rate; QoL: quality of life; SD: standard deviation.

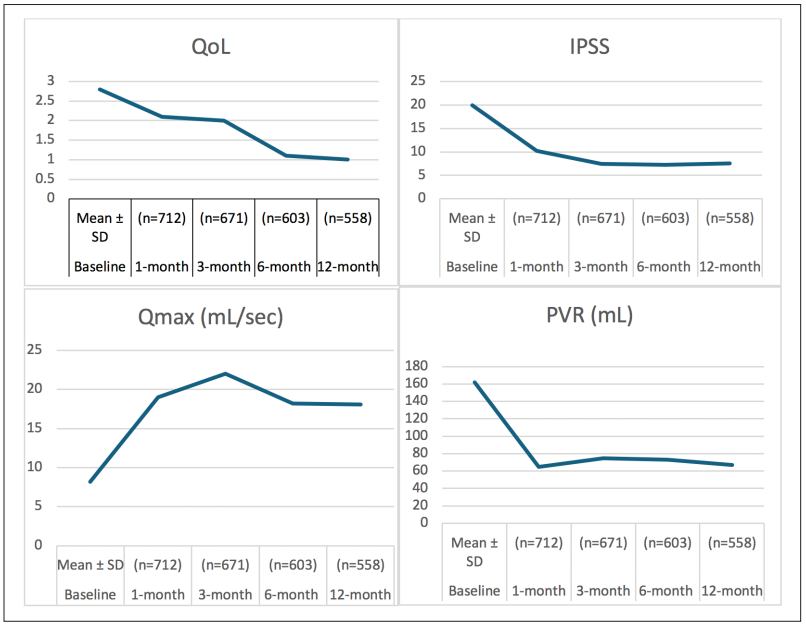

Figure 1. Functional outcomes at the first-year followup visits. IPSS: International Prostate Symptom Score; PVR: postvoid residual; Qmax: peak flow rate; QoL: quality of life; SD: standard deviation.

Table 3. Comparison of perioperative parameters among different GreenLight laser generations

Variable	80 W KTP (n=114)	120 W HPS (n=175)	180 W XPS (n= 423)	p
Age (years)	73.1±8.0	73.5±7.5	74.8±9.0	0.62
Prostate volume (mL)	42.0±17.5	49.9±22.5	74.1±24.1	<0.001
Operation time (min)	51.5±7.4	66.4±3.2	91.9±37.1	0.001
Lasing time (min)	45.9±23.5	57.1±32.0	49.0±2.9	0.02
Total energy used (kJ)	149.78±71.6	150.59±99.1	259.1±134.45	<0.001
Catheter time (day)	1.67±1.59	0.40±1.92	1.2±1	0.15
Hospital stay (day)	1.04±0.6	1.1±0.74	1.3±0.9	0.60

HPS: high-performance system; KTP: potassium titanyl phosphate; XPS: xcelerated performance system.

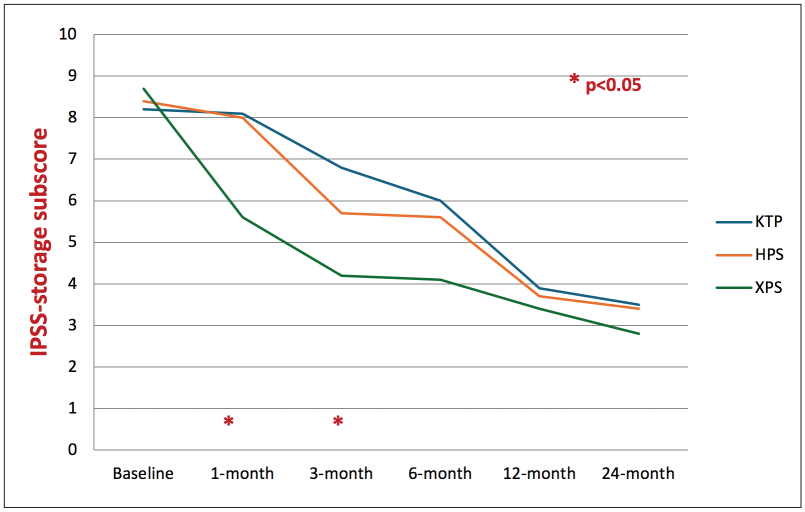

Figure 2. Changes in IPSS-storage subscores among the three GreenLight laser generations at different followup periods. HPS: high-performance system; IPSS: International Prostate Symptom Score; KTP: potassium titanyl phosphate; XPS: xcelerated performance system.

izing large prostates, making it better suited for small to moderate gland volumes. In contrast, the 180 W XPS laser (third generation) provides higher power with enhanced vaporization and coagulation efficiency, making it more effective for treating larger prostates (>80–100 mL). This likely explains why larger prostates in our cohort were preferentially treated with the 180 W XPS system.

Interestingly, our data show laser type-dependent decrease in storage symptoms. The 180 W XPS laser led to better storage symptoms more rapidly, despite its significantly longer operation time and higher total energy used compared to the two other types. Perhaps the reason resides in the increased learning curve, as shown by the laser time associated with the 180 W XPS laser, which appears to be in the lower end compared to other laser generations. Extrapolating the idea, this may further support the observed storage improvements following enucleation considering vapoenucleation in the 180 W XPS system.

Limitations

Despite our study's merits, it is not without its limitations. First, the retrospective nature could contribute to selection bias; however, the data used in the present study was collected prospectively. Additionally, only a subset of patients (124 of 712) had followup exceeding 10 years, introducing potential attrition bias. This is a recognized limitation of retrospective, long-term studies, particularly in surgical cohorts where patients who experience significant symptomatic improvement often discontinue routine followup.

Furthermore, three generations of GreenLight laser systems were used over the 15-year study period, which may have introduced variability in technical outcomes. We addressed the differences between each laser generation within the present study, which we believe adds valuable insight into the evolution of the PVP technique over time. Nevertheless, the large sample size and extended followup period strengthen the relevance of our findings, providing important reference data for long-term patient counseling regarding GreenLight PVP outcomes.

Finally, sexual function outcomes were not assessed in this study. We acknowledge this as a limitation and recommend that future studies incorporate validated measures of sexual function to provide a more comprehensive evaluation of patient outcomes following GreenLight PVP

CONCLUSIONS

Our long-term functional outcomes support the durability of the GreenLight laser PVP with acceptable long-term adverse events after a decade of surgery. Patients should be advised that they may experience postoperative dysuria, which might last up to three months after surgery. Further prospective studies are required to identify the potential risk factors of dysuria after GreenLight laser PVP.

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