GreenLight laser prostatectomy: Are outcomes sustainable after a decade of surgery? A single-center experience with up to 15 years of followup

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ABSTRACT

Introduction: We aimed to report our single-center experience with long-term outcomes of GreenLight laser prostatectomy 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 anitgen (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 present 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 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 which 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 eight decade of life, causing 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 as the gold standard treatment for BPH.(4) In the mid-1990s, the urological 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 surgical treatment of BPH.(6)

While several studies demonstrated the feasibility and safety of the GreenLight PVP, few have assessed the durability of the PVP technique over long-term follow-up (>10 years).(7–9) The recent large-scale study was conducted by the Global GreenLight Group.(8) They used a multi-center, international database of patients undergoing PVP with a median follow-up of 6 months, they demonstrated the safety and effectiveness of the PVP surgery in experienced hands.(8) Furthermore, Ajib K *et al*, demonstrated the durability, efficacy, and safety of the GreenLight PVP over a five-year experience.(9) However, there is paucity in the literature quantifying long-term outcomes (> 10 years) of GreenLight PVP. Therefore, the aim of the current study is to present our experience regarding long-term surgical outcomes, complications rate and durability of GreenLight PVP over a period of 15 years.

METHODS

Study design

A prospectively collected database of patients undergoing GreenLight Laser PVP for symptomatic BPH with data collected between 2005 and 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 post-operative complications, total operative time, ASA (American Society of Anaesthesiologists) score, International Prostate Symptom Score (IPSS) including quality of life (QoL), peak flow rate (Qmax), post-void residual urine volume (PVR) and prostate specific antigen (PSA) levels. Patients were followed at 1, 3, 6 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 symptoms scores were collected and compared at baseline and at follow-up 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/80W, HPS/120W and XPS/180W laser systems (*AMS, Minnetonka, MN*), 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 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 follow-up 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 follow-up 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 regards 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 3 months after surgery, and 12 patients (1.7%) developed post-operative epididymo-orchitis (Table 1).

Regarding long-term adverse events, persistent lower urinary tract symptoms (LUTS) were encountered in 15 patients (2.1%), repeat surgery for adenoma regrowth in 24 patients (3.3%), stress urinary incontinence (SUI) in 9 cases (1.2%), bladder neck contracture (BNC) in 18 cases (2.5%), urethral stricture in 15 cases (2.1%), and bladder stone in 3 cases (0.4%) (Table 1). At long-term follow-up (>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 follow-up of 12.1 (10-15) years, only 124 patients of the cohort exceeded 10 years of follow-up. 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 follow-up (Table 2).

Likewise, there was a significant increase in Qmax (8.2 to 17.7 ml/sec, $p<0.001$) with 64.2 % PSA reduction from baseline (Table 2). The trend of improvement of the functional outcomes during different follow-up visit was presented in Figure 1. Additionally, 20.5% of patients required the resumption of medical therapy (alpha-blockers, β3-agonists, or anticholinergics) during follow-up, primarily due to the recurrence of lower urinary tract symptoms (LUTS) or the development of storage symptoms over time.

The perioperative parameters among the three different GreenLight generations were described in Table 3. Operating time with KTP-80W (51.5 min) and lasing time (45.9 min) were significantly lower than others. It is noteworthy that 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 nor hospital stay duration. The XPS-180W laser machine appeared to achieve more pronounced decline in storage symptoms earlier postoperatively compared to KTP and HPS machines (Figure 2).

DISCUSSION

Currently, there are several minimally invasive treatment options for management of symptomatic BPH. The GreenLight 532-nm laser PVP, which is selectively absorbed by hemoglobin, is a safe and feasible treatment option in surgical management of BPH.(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 make it more feasible and convenient technique when compared to other treatment modalities such as enucleation.(7) Consequently, recent AUA and EAU guidelines have recommended the use of GreenLight laser PVP for the treatment of symptomatic BPH ≤ 80 gm. (13,14) While several studies have demonstrated the safety and efficacy of GreenLight laser PVP in surgical treatment of BPH, to date, there are scanty of studies that showed encouraging long-term functional results over 5 years of follow-up.(15) Therefore, the aim of the present study was to present our institution's long-term experience with GreenLight laser PVP over a period of 15 years.

With regards to functional outcomes, our study revealed significant improvements in IPSS and QoL scores, Qmax, and PVR at early follow-up visits (Figure 1) and these results were maintained over a median follow-up of 12.1 years (Table 2; $p<0.05$***)***. Likewise, a 65% reduction in PSA values persisted over the entire follow-up period (Figure 1). These findings confirm the durability of PVP technique for 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 seldom as demonstrated by the results of the present study. It was found that the rate of blood transfusion in our study was quite low (0.4%). This could be attributed to the physics of the GreenLight laser which is selectively absorbed by hemoglobin resulting in superior hemostasis. All 3 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 trial of void (TOV) after surgery. They were managed conservatively and with alpha blocker medications until eventually voided within the first month of surgery and only 0.8% of them required repeat surgery for regrowth adenoma. Additionally, 6.2% had persistent dysuria which lasted for 3 months after surgery (Table 1). The mechanism of postoperative dysuria after GreenLight laser PVP could be explained by two main factors. First, the shorter laser wavelength (532nm) of the GreenLight results in deeper tissue penetration compared to other laser sources such as the Holmium:YAG laser. Secondly, the high intraprostatic temperature yielded from the GreenLight laser beam also causes coagulative necrosis of prostatic tissue as well as vaporization. Therefore, we believe that the risk of post-operative dysuria should be divulged to the patient prior GreenLight laser PVP surgery.

Moreover, few long-term complications may occur such as stress urinary incontinence (SUI) in 0.3%, bladder neck contracture in 1.3% and urethral stricture in 1.0%. Likewise, the reoperation rate in our cohort was also quite low (0.8%). These findings might reinforce the safety, sustainability, and durability of the PVP technique over long-term follow-up.

The results of the present study were also consistent with what was found by Batura *et al*. after a 2-year follow-up, namely a 47% reduction from PSA at baseline, 64% improvement in Qmax. In terms of complications, they noted more stricture (3.4%) and 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 follow-up of 30 months using the 80W laser.(17) In another large multi-center 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 3-year follow-up.(18) Persistent LUTS and urinary incontinence are also relevant complications worth mentioning as they strongly impact QoL negatively.(19) In the latter 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 2 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 that were anticoagulated. Our data aligns with previous studies.(21,22)

It is imperative to recognize that different GreenLight laser generations (80W KTP, 120W HPS, and 180W XPS) possess varying power outputs and tissue ablation capabilities. The KTP-80W laser (first generation) was relatively less powerful and slower at vaporizing large prostates, making it better suited for small to moderate gland volumes. In contrast, the XPS-180W laser (third generation) provides higher power with enhanced vaporization and coagulation efficiency, making it more effective for treating larger prostates (e.g., >80–100 mL). This likely explains why larger prostates in our cohort were preferentially treated with the XPS-180W system. Interestingly, our data show laser type-dependant decrease in storage symptoms. XPS/180W laser led to better storage symptoms more rapidly as demonstrated by steeper curve in Figure 2, despite its associated significant 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 XPS/180W which appears to be in lower end compared to other laser generations. Extrapolating the idea, this may further support the observed storage improvements following enucleation considering vapoenucleation in XPS/180W system.

Limitations

Despite our study's merits, it is not without its limitations. First, the retrospective nature could attribute to the selection bias. However, the data used in the present study was collected prospectively. Additionally, only a subset of patients (124 out of 712) had follow-up 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 follow-up. Second, 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 follow-up period strengthen the relevance of our findings, providing important reference data for long-term patient counseling regarding GreenLight PVP outcomes. Third, 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 3 months after surgery. Further prospective studies are required to identify the potential risk factors of dysuria after GreenLight laser PVP.

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FIGURES AND TABLES

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

Figure 2. Changes in IPSS-storage sub-scores among the three green light laser generations at different followup periods. IPSS: International Prostate Symptom Score.

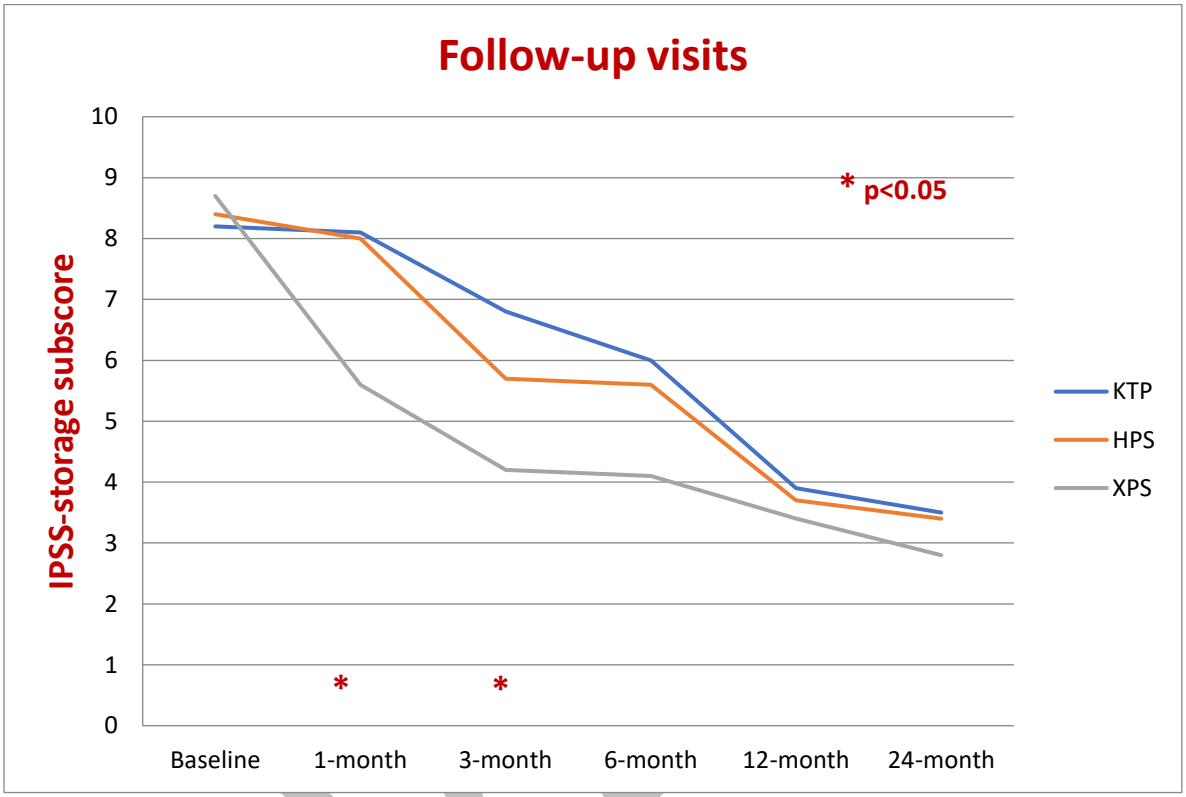

Table 1. Demographic and perioperative data with long-term complications		
Variables		**Mean±SD** **n (%)**
Age at time of surgery (years)		73.9±7.8
Patients with diabetes mellitus		5 (0.7)
Preoperative medications for LUTS		118 (16.6)
Patients with indwelling urethral catheters		32 (4.5)
Preoperative PSA (ng/dl)		5.3±4.2
Preoperative IPSS		19.9±5.5
Preoperative QoL		2.8±1.5
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; TRUS: transrectal ultrasound.

Table 2. Long-term functional outcome after 10–15 years of 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.

Table 3. Comparison of perioperative parameters among different GreenLight laser generations				
Variable	**KTP-80W (n=114)**	**HPS-120W (n=175)**	**XPS-180W (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

KTP: potassium titanyl phosphate, HPS: high performance system, XPS: Xcelerated performance system.