Holmium Laser Enucleation of the Prostate: Efficiency Gained by Experience and Operative Technique

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Purpose: Holmium laser enucleation of the prostate is highly effective for symptomatic benign prostatic hyperplasia. Despite its steep learning curve the procedure is an efficient treatment, especially for large prostate glands. We determined the change in enucleation efficiency with time with increased operative experience and improved technique.

Materials and Methods: We reviewed the records of all 949 consecutive men who underwent holmium laser enucleation of the prostate between 1999 and 2007. Patients were excluded from analysis when enucleated gm or time was not recorded and enucleated tissue was less than 5 gm. Efficiency was measured in gm enucleated prostate tissue per minute. Descriptive statistics on laser time, gland weight and efficiency were evaluated in an 8-year period.

Results: A total of 91 patients met study exclusion criteria, leaving 858 available for evaluation. Mean enucleation time was 94 minutes (range 12 to 485). Mean prostate specimen weight was 77 gm (range 5 to 376). Mean efficiency or enucleation rate was 0.55 vs 1.32 gm per minute in the first 4 vs the last 5 years. Further efficiency improvements were noted in the last 5 years with a mean of 1.57 gm per minute enucleated in the last 2 years.

Conclusions: As experience with holmium laser enucleation of the prostate grows, advances in operative technique have been made. Prostatic enucleation efficiency continues to improve, further strengthening the role of holmium laser enucleation of the prostate for benign prostatic hyperplasia of small and large prostate glands.

Key Words: prostatic; prostatic hyperplasia; lasers, solid-state; prostatectomy; transurethral resection of prostate

Abbreviations and Acronyms

BPH = benign prostatic hyperplasia

HoLEP = prostate holmium laser enucleation

TURP = transurethral prostate resection

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Holmium laser enucleation of the prostate has emerged as an effective transurethral treatment option in patients with symptomatic BPH of any size.[1] Several single center and multicenter series have documented HoLEP efficacy and safety.[1–19] In the last 10 years this minimally invasive surgical technique has been the most rigorously studied of any BPH therapy with multiple randomized clinical trials comparing its efficacy to that of TURP[6–8,10–11,19] and open simple prostatectomy.[2,5,6,9,18] On urodynamic measures HoLEP is the only endourological procedure to date to provide relief of bladder outlet obstruction superior to that of TURP.[10] Sustained results have been observed up to 6 years postoperatively with a less than 2% re-treatment rate.[12]

Despite the benefits of HoLEP the procedure has been slow to gain widespread acceptance. HoLEP is per-

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ceived as having a steep learning curve that requires specialized training to overcome.[20] Others have reported that the procedure requires significant endoscopic skill and longer procedure time is common.[21] To minimize the learning curve associated with the procedure technical advancements, such as an easy to use mechanical morcellator[19] and alterations in surgical technique, have been introduced. As expected, procedure efficiency has improved with experience but we suggest that alterations in surgical technique have produced improvements greater than expected by experience alone. We present our 8-year experience with HoLEP and evaluate the efficiency of laser enucleation in varying gland sizes with time.

MATERIALS AND METHODS

After receiving institutional review board approval we retrospectively reviewed the records of 949 consecutive men who underwent HoLEP between January 1999 and October 2007 at Methodist Hospital of Indiana, as done by a single urologist (JEL) with associated residents and fellows. Patients without recorded tissue weight or enucleation time were excluded from analysis. To focus on the complete HoLEP procedure and exclude only partial enucleation or bladder neck incision we also excluded enucleated glands less than 5 gm. A total of 91 patients met exclusion criteria, leaving 858 available for review. The level of resident and fellow involvement varied by case. Thus, the learning curve of the urologist was also affected by the learning curve of each involved resident or fellow depending on the level of comfort with HoLEP. The amount of resident or fellow involvement was not controlled but remained consistent throughout the cohort.

The surgical technique used for HoLEP was previously described.[13] However, certain aspects of our technique have evolved with time. 1) The median prostate lobe was incorporated into one of the lateral lobe dissections in almost all cases, limiting posterior dissection to only 1 groove. 2) Dissection is now started at the apex lateral to the verumontanum where the plane between capsule and adenoma is prominent. 3) Dissection is carried around the lateral margin of the gland across the anterior surface to open a space that serves as a target at the time of division of the anterior commissure. 4) The apical mucosal strip is divided by encircling the adenoma with the endoscope and placing the tissue on stretch away from the sphincter. 5) For large adenomas that do not easily displace into the bladder we morcellate the tissue in the prostatic fossa before completing enucleation.

During each case enucleation time and prostate specimen weight were recorded. Enucleation time was recorded in minutes from the start of laser dissection to complete detachment of the adenoma from the prostatic capsule. This time did not include morcellation since this is linearly related to specimen weight.[22] Prostate specimen weight was recorded in gm as the final pathological weight provided by the pathologist. Efficiency was calculated in gm prostate enucleated per laser enucleation time in minutes, conforming to other efficiency studies using a specimen retrieved per time standard.[22]

Comparisons were made over the entire cohort and in stratified groups by gland size, including small—less than 50, medium—50 to 100 and large—greater than 100 gm. We also compared earlier (1999 to 2002) and later (2003 to 2007) years. Case number was used to represent experience with time with higher case numbers representing more recent cases. The first case in January 1999 was recorded as case 1.

Descriptive statistics, including the mean, median, minimum and maximum, were calculated across all cases for gland weight in gm, enucleation laser time in minutes and enucleation efficiency in gm per minute. The relationship between laser time and specimen weight during the case experience was explored by scatterplots and calculating Pearson correlation coefficients. Laser enucleation efficiency was shown graphically by year using box plots constructed with the values of quartiles 1 and 3, and median with whiskers with a maximum length of 1.5 IQR. Mean laser time was compared across subgroups, adjusting for gland weight using ANCOVA. Laser efficiency was compared between large and small/medium glands using the 2-sample Student t test with $p < 0.05$ considered significant. All statistical analysis was done with SPSS® for Windows® and R (2.4.1).

RESULTS

In the 858 patients studied mean age was 71 years (range 48 to 95). Mean estimated preoperative transrectal ultrasound prostate volume was 99 cc (range 5 to 309.5). Mean enucleated gland weight was 77 gm (median 68, range 5 to 376). Of the prostates 230 were larger than 100 gm, 352 were between 50 and 100 gm, and 276 were less than 50 gm. There were no major intraoperative complications but 2 men required perineal urethrostomy due to large prostate size and 1 required open cystotomy to remove the enucleated adenoma due to morcellator malfunction. Pathological evaluation of retrieved specimens revealed malignancy in 86 men (10%) and benign hyperplasia in 772 (90%).

In all procedures mean laser time was 94 minutes (median 85, range 12 to 485). Mean efficiency in all glands was 1.0 gm per minute (median 0.8, range 0.1 to 5.1). The table lists specimen weight, laser time and efficiency by year.

Scatterplots of gland weight and laser time by case number revealed how specimen weight, laser time and efficiency changed during the case experience (fig. 1). There was a small increase in gland weight with time but the correlation of gland weight with case number was weak ($r = 0.14$). A substantial decrease in laser time was evident over the case experience, as shown by a moderate negative correlation between laser time and case number ($r = -0.53$). Similarly a positive correlation was found between laser time efficiency and case num-

Enucleated specimen weight, laser time and calculated efficiency of all HoLEPs from 1999 to 2007

Yr	No. Pts	Mean Wt (range) (gm)	Mean Laser Time (range) (mins)	Mean Efficiency (range) (gm/min)
1999	41	60 (7–224)	112 (51–280)	0.5 (0.1–1.8)
2000	101	63 (5–210)	136 (50–350)	0.5 (0.1–2.2)
2001	98	74 (6–376)	126 (25–473)	0.6 (0.1–1.5)
2002	93	78 (7–284)	143 (20–286)	0.6 (0.1–2.8)
2003	137	81 (5–271)	84 (22–165)	1.0 (0.2–3.4)
2004	134	77 (6–224)	12 (76–485)	1.2 (0.1–5.1)
2005	117	78 (8–182)	58 (20–169)	1.5 (0.1–4.9)
2006	85	85 (6–240)	60 (21–135)	1.5 (0.2–3.8)
2007	52	94 (9–314)	56 (14–162)	1.8 (0.4–5.1)
Totals	858	77 (5–376)	94 (12–485)	1.0 (0.1–5.1)

ber ($r = 0.50$). Box plots of efficiency by year showed a pattern of increased efficiency across years of experience (fig. 2).

The effect of experience on procedure time was further examined by dividing the cohort into early (1999 to 2002) and late (2003 to 2007) groups. In 2003 we significantly altered our surgical technique, providing the rationale for the cohort grouping. After adjustment for gland size mean laser time in the late group was significantly shorter than in the early group (69.8 vs 131.9 minutes, $p < 0.001$).

For large glands (greater than 100 gm enucleated) a substantial decrease in laser time was evident over case experience, as shown by a moderate negative correlation between laser time and case number ($r = -0.644$, fig. 3). However, there was no substantial increase in gland weight by case number ($r = 0.005$). In contrast to glands of other sizes in this cohort, overall enucleation was significantly more efficient in larger than in medium and small glands (1.71 vs 0.77 gm per minute, $p < 0.001$).

DISCUSSION

HoLEP continues to gain academic support since multiple studies have shown outcomes comparable to those of open prostatectomy and TURP with significantly lower morbidity. HoLEP also has long-term durability.[1–19,22] Despite the obvious advantages of HoLEP misconceptions about its steep learning curve and financial cost have led to limited acceptance of this technique. Investigators have reported that after the initial investment for the laser is factored out HoLEP is more cost-effective than TURP and open prostatectomy due to shorter hospitalization and a decreased need for ancillary interventions, ie blood transfusion and continuous bladder irrigation.[9,23,24] Studies have shown that a surgeon familiar with transurethral surgery should be competent to perform HoLEP after only 20 to 30 cases.[2,7,9,25,26] To further dispel the myths associated with HoLEP we reviewed our 8-year experience with the procedure at a high volume training institution to demonstrate the progress in surgical technique with time.

We evaluated more than 850 HoLEP procedures done at our institution from 1999 to 2007. During the 8-year period laser time decreased as case experience increased. Since HoLEP is ideally suited for large prostates, we further focused on men with greater than 100 gm enucleated and found that the decrease in laser time was most pronounced in these patients. We also reviewed the efficiency of enucleation or the laser enucleation rate in gm per minute, and found that this parameter improved with years of experience and again was best for glands larger than 100 gm. Unlike prior groups we focused on laser time to evaluate efficiency and excluded morcellation time. We examined only actual laser time since this portion of the procedure is subject to potential improvements in surgical technique while morcellation time depends primarily on morcellator technology.

Previously investigators at our institution reported the reproducibility and efficiency of HoLEP in a 3-year period. In 2005 Kim et al detailed efficiency between 40 matched patients at 2 high volume HoLEP centers, Methodist Hospital, Indiana, and Taurranga Hospital, New Zealand.[22] In the previous comparison morcellation time was included and average efficiency was 0.52 gm per minute. Efficiency also increased with increasing gland size. To compare our prior study to the current study efficiency could be adjusted to 0.71 gm per minute by removing the mean 9.9-minute morcellation time from the efficiency calculation.[22] This difference in calculation should be remembered when comparing articles. Average efficiency in our current series is 0.77 gm per minute, representing a 0.07 gm per

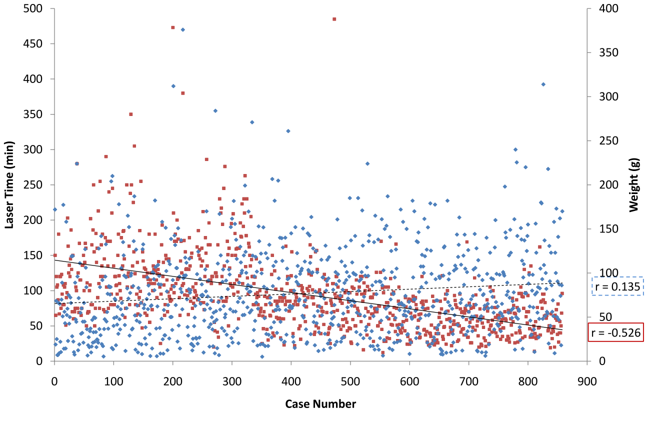

Figure 1. Laser time (red dots, solid curve) and specimen weight (blue dots, dotted curve) by case number in prostates of all sizes treated with HoLEP.

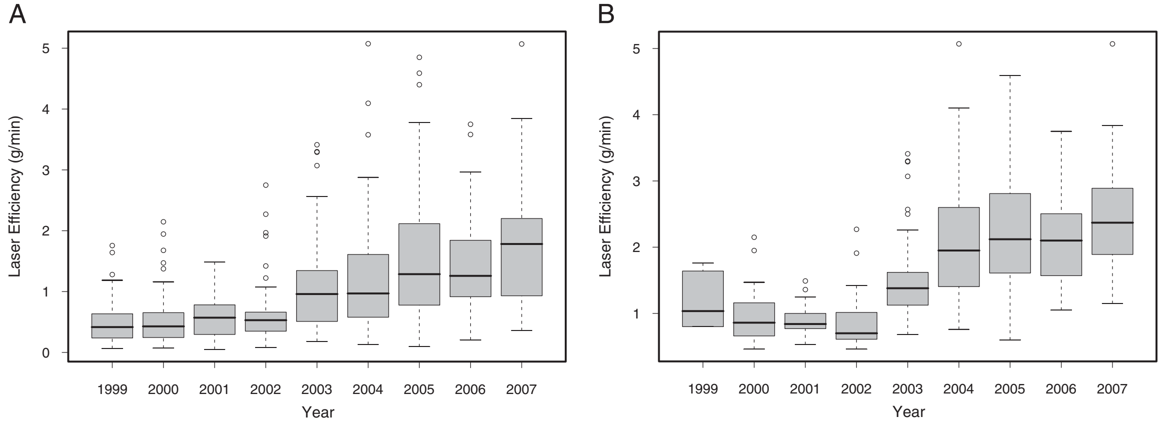

Figure 2. HoLEP enucleation efficiency in prostate from 1999 to 2007. *A*, glands of all sizes. *B*, glands greater than 100 gm.

minute improvement over our prior data. When we further analyzed our current data as early and late pooled groups, we again found improved efficiency with time. This effect was most pronounced for 2003 to 2007 after adopting the technical modifications detailed in this series.

A possible explanation for the improved HoLEP efficiency is further experience. However, the surgeon in our series was well past the learning curve of 20 to 30 cases after year 1. Advancements in surgical technique are a more likely explanation. Since initiating HoLEP at our institution, several alterations have been made in the technique. The first alteration was to make a solitary posterior groove and incorporate median lobe dissection into one of the lateral lobes. Developing a posterior groove can be significantly time consuming, especially for large glands. Thus, limiting it to only 1 groove can save several minutes and is technically feasible for all except the most massive of median lobes. The second advancement was initiation of enucleation at the apex lateral to the verumontanum, as opposed to 12 o'clock anterior. We found that the plane between adenoma and capsule is prominent at this site and easy to identify. Dissection is then carried lateral and circumferential to extend the dissection plane across the anterior aspect of the prostate, which is our third modification. Creation of the anterior potential spaces provides an easily identifiable target when the anterior commisure is divided to separate the right from the left lateral lobe of the prostate. Our fourth modification enables easy identification of the apical mucosal strip and limits the risk of potential sphincteric damage. After the anterior lateral and posterior aspects of the distal prostate are enucleated the endoscope is encircled around the prostate, starting anterior, moving posterior and then pulled distal, allowing the strip to present on tension for easy division away from the sphincter muscle. Finally, for large glands it can be difficult to deposit the enucleated adenoma into the bladder and significant time may be spent trying to unsuccessfully relocate it into the bladder to allow the completion of posterior dissection. In these challenging cases we simply stop enucleation and morcellate the tissue in the prostatic fossa down to a small tissue stalk that can be easily manipulated, allowing the completion of enucleation.

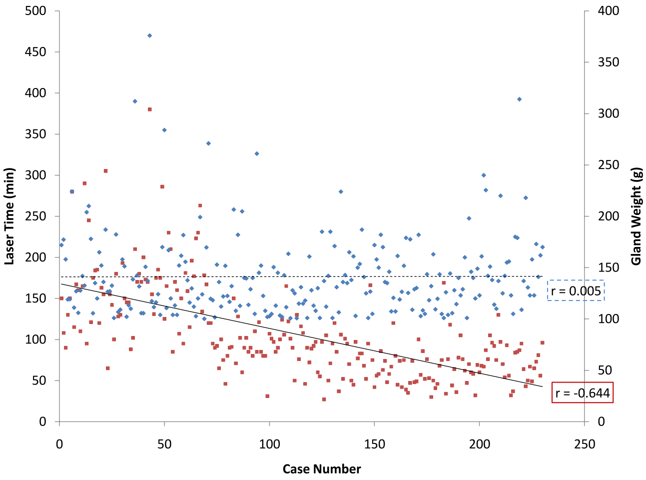

Figure 3. Laser time (red dots, solid curve) and specimen weight (blue dots, dotted curve) by case number in prostates greater than 100 gm treated with HoLEP.

In the current study HoLEP efficiency increased as prostate size increased. To our knowledge this phenomenon has not previously been reported for other endoscopic prostate procedures. In fact the risk of adverse effects, such as bleeding and transurethral resection syndrome, increases with the TURP procedure proportionally as gland size increases.[27] Conversely several groups have noted the safety and effectiveness of HoLEP for large prostates.[2,9,13,15,18,19,25] Despite all the compelling evidence that HoLEP is the ideal procedure for small as well as massive gland BPH a recent Austrian survey showed that approximately 10% of surgical procedures for BPH are still open.[28] It would not be unreasonable to expect similar results in other industrialized nations. Furthermore, laparoscopic simple prostatectomy[29] and now even robotic prostatectomy[30] are being used for large gland BPH to create a minimally invasive treatment alternative. Our endeavor is that with further technical advancements and supportive data HoLEP will become widely available to allow the maximal benefit to patients using this natural orifice procedure while avoiding the associated morbidity and potential inferior outcomes of other available treatment modalities.

Certain limitations of the study must be recognized. 1) This is a retrospective review. However, all data on patients undergoing HoLEP at our institution are collected prospectively as part of an institutional review board approved database. Only patients with complete followup information available were included in the study. 2) All procedures were performed by 1 surgeon but residents and fellows participated in the cases. The amount of resident/fellow participation varied by case and almost certainly introduced some degree of bias. However, the primary surgeon was present and proctored all cases. This likely accounted for the continued improvement seen with time and served as a control in all cases. Despite these limitations this study shows the continued improvement in HoLEP with time as familiarity with the technique was gained while simplifying the procedure.

CONCLUSIONS

The efficiency of prostatic enucleation via the HoLEP technique improves with time. This improvement in laser enucleation time is most likely a result of increasing experience as well as improvements in surgical technique, which have simplified the procedure. Efficiency is greatest in larger glands, making HoLEP an ideal treatment option in patients once traditionally treated with simple prostatectomy.

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