Holmium laser for the surgical treatment of benign prostatic hyperplasia

Portia Thurmond, MD,[1] Sanchita Bose, MD,[2] Lori B. Lerner MD[1,2]

[1]Veterans Affairs Healthcare System, Boston West Roxbury, Massachusetts, USA

[2]Boston University Medical School, Boston, Massachusetts, USA

THURMOND P, BOSE S, LERNER LB. Holmium laser for the surgical treatment of benign prostatic hyperplasia. *Can J Urol* 2016;23(4):8356-8362.

Introduction: *Holmium laser ablation of the prostate (HoLAP) is a surgical approach for treatment of benign prostatic hyperplasia (BPH). Limited evidence suggests laser ablation/vaporization is inferior to enucleation with respect to reoperation rates. Our objective was to determine if properly performed laser ablation results in outcomes similar to enucleation.*

Materials and methods: *A total of 198 patients with moderate to severe lower urinary tract symptoms and/or acute urinary retention had holmium laser enucleation of the prostate (HoLEP) or HoLAP between 2008 and 2014. Patients with metastatic prostate cancer, prior pelvic radiation, or bladder cancer involving the bladder neck or prostatic urethra were excluded. All procedures involved residents and were supervised by one experienced surgeon. The decision to perform HoLAP versus HoLEP was made intraoperatively. Demographics, pre, peri and postoperative data were collected.*

Results: *A total of 169 men were analyzed: 54 had HoLAP and 115 had HoLEP. Mean follow up was 27.16 months for HoLAP, and 38.18 months for HoLEP. As expected, the HoLEP group had larger prostates, longer mean operative times, and greater reduction in total PSA. There was no difference in the net change of flow rate between groups.*

Conclusion: *Both HoLEP and HoLAP are appropriate surgical interventions for the management of BPH, when properly performed. Our findings suggest that adequate ablation of prostatic adenoma results in similar 2 year outcomes as enucleation.*

Key Words: benign prostatic hyperplasia, holmium, holmium lasers, holmium-YAG lasers, transurethral visual laser ablation of the prostate, transurethral resection of the prostate, HoLEP, HoLAP

Introduction

Benign prostatic hyperplasia (BPH) is defined as non-cancerous enlargement of the prostate and can be associated with voiding symptoms among aging men.[1-4] There is no consensus on the etiology of BPH and several studies have suggested inflammatory, endocrine, and vascular causes for the benign enlargement.[5-7] For this reason, treatment of BPH is clinically challenging, in some cases requiring both medical and surgical management.[8]

With regard to surgical therapy to mitigate the sequelae of symptomatic BPH, there are a wide range of approaches including open surgery; transurethral resection with electrocautery and laser based modalities; as well as laparoscopic and robotic-assisted techniques.[9] Transurethral resection of the prostate (TURP) using electrocautery has been the longstanding gold standard, although laser approaches have been shown to be equally as effective and have recently challenged TURP for the title.[10,11] In particular, holmium laser provides better homeostasis, removes

Accepted for publication July 2016

Address correspondence to Dr. Lori B. Lerner, 12 Water Street, Hingham, MA 02043 USA

more adenoma, and requires shorter catheter times than TURP.[12-14] Despite this, the steep learning curve of holmium laser enucleation of the prostate (HoLEP) and technical difficulties with morcellation have been barriers to widespread adaptation.[15-17]

While most urologists associate holmium laser energy with enucleation, it can also be used to ablate the prostate (holmium laser ablation of the prostate, or HoLAP). In prostates less than 60 g, HoLAP may be the preferred strategy for management of BPH.[18-20] While some studies have suggested that laser ablation is less effective than TURP with respect to long term outcomes, there are conflicting data.[20,21] To our knowledge there has been no study directly comparing the outcomes of holmium ablation with holmium enucleation. The purpose of this study is to compare outcomes of patients treated with HoLAP to HoLEP, and determine if, and when, ablation is an acceptable alternative.

Materials and methods

Approval for this study was obtained from the VA Boston Healthcare System Internal Review Board. Patient data were collected at the initiation of a new laser program at the VA Boston Healthcare System and continued during the majority of the lead author's tenure. Between April 2008 and February 2014, all patients with mild to moderate lower urinary tract symptoms (LUTS) or urinary retention who underwent HoLEP or HoLAP were identified for inclusion in the study (not including patients who underwent laser incision of the prostate and/or bladder neck incision). Patients with metastatic prostate cancer, prior pelvic radiation, planned staged procedures, or bladder cancer that involved the bladder neck or prostatic urethra were excluded. All procedures involved residents and were supervised by a single experienced surgeon. Urodynamic testing was performed at the discretion of the operating surgeon, and routinely performed in patients with complicated voiding patterns, such as those with incontinence, urge/overactive bladder, and/or neurologic disease.

Enucleation was completed utilizing the technique outlined by Gilling, while ablation utilized a modification of techniques described by Gilling and Tan and described elsewhere.[9,22-24] Both techniques use the surgical capsule as a point of reference. Enucleation is complete resection of adenoma along the surgical capsule, while ablation is complete laser vaporization of adenoma from mucosal surface to the surgical capsule. The decision to perform holmium ablation versus enucleation was made intraoperatively based on anatomic characteristics of the prostate. In general, ablation was chosen when glands were short, smaller, had a bilobar occlusive pattern as opposed to trilobar, and there was no evidence of intravesical prostatic protrusion. No patients were converted from one approach to the other at any point during the surgery. For both procedures, laser settings were standardized at 2 Joules and 50 Hertz. Postoperative management of patients was the same regardless of approach.

Data were collected, when available, on patient demographics, prostate size, PSA (preoperatively and 1 year postoperatively), flow rates (preoperatively and 6-8 weeks postoperatively), bladder outlet obstruction index (BOOI), medical history, anticoagulation prior to surgery, operative time, intraoperative complications, postoperative complications at 30 days and at 1 year, and reoperation rates for the full time period of the study. PSA has been shown to correlate well with prostate size, and was used as a surrogate for prostate size in this study.[25,26] Transurethral ultrasound (TRUS) or other imaging measurements were compared, when available. Use of 5-ARI for longer than 6 months was compared.

Univariate analysis was performed to determine means and standard deviations for continuously coded variables. Complications were classified according to the Clavien Classification system.[27,28] Body mass index (BMI) categories, composite International Prostate Symptom Score (IPSS) categories, reoperation, medical history, and medication status were treated as categorical variables; wherein frequencies and proportions were generated. Categorical data were compared using Chi-square test and continuous data using Student's t-test. All tests were two sided with a statistical significance set at $p < 0.05$. Analyses were conducted using STATA statistical software.[29]

Results

A total of 198 patients were identified as having holmium laser prostate surgery between April 2008 and February 2014. After exclusions, a total of 169 men were included in the analysis: 54 had HoLAP and 115 had HoLEP. Demographic information and outcomes are outlined in Table 1. The mean follow up for each group was 27 months for the HoLAP group and 38 months for the HoLEP group.

Men in the HoLAP group were similar in age, BMI and American Society of Anesthesiologists' (ASA) physical status score. They were also similar in terms of medical history, with no difference between the groups regarding diagnosis of urinary tract infection (UTI) in the year before surgery, diabetes mellitus (DMII), coronary artery disease,

TABLE 1. **Demographics and preoperative characteristics**

	HoLAP (n = 54)	HoLEP (n = 115)	p value
Age, y (± SD)	68.33 (8.91)	67.13 (7.75)	0.3718
BMI, kg/m^2 (± SD)	29.19 (4.61)	30.69 (5.28)	0.0775
ASA (± SD)	2.77 (0.54)	2.81 (0.56)	0.6896
BOOI (± SD)	70.44 (34.78)	67.25 (28.12)	0.6528
Preoperative PSA, ng/dL (± SD)	3.26 (4.49)	6.30 (6.09)	0.0017*
Preoperative DRE, g (±SD)	37.72 (12.12)	46.12 (16.50)	0.0031*
Preoperative TRUS, cc (±SD)	52.45 (38.05)	81.06 (40.18)	0.0017*
Preoperative Qmax , cc/s (±SD)	6.59 (3.44)	7.22 (4.34)	0.4241
Anticoagulation preop			
No (%)	19 (35.19)	53 (46.90)	
Yes (%)	35 (64.81)	60 (53.10)	0.1530
Diabetes, type II			
No	41 (75.93)	86 (75.44)	
Yes	13 (24.07)	28 (24.56)	0.9450
Hypertension			
No	16 (29.63)	39 (33.91)	
Yes	38 (70.37)	76 (66.09)	0.5790
Coronary artery disease			
No	40 (75.47)	86 (74.78)	
Yes	13 (24.53)	29 (25.22)	0.9240
Neurological disease			
No	47 (87.04)	107 (93.04)	
Yes	7 (12.96)	8 (6.96)	0.2470
Anticholenergics			
No	43 (79.63)	103 (89.57)	
Yes	11 (20.37)	12 (10.43)	0.0790
Alpha-blockers			
No	11 (20.37)	22 (19.13)	
Yes	43 (79.63)	93 (80.87)	0.8500
5-alpha reductase inhibitors			
No	32 (59.26)	53 (46.09)	
Yes	22 (40.74)	62 (53.91)	0.1100
Clean intermittent catheterization			
No	45 (83.33)	92 (80.00)	
Yes	9 (67)	23 (20.00)	0.6060
Indwelling catheter			
No	47 (87.04)	101 (87.83)	
Yes	7 (12.96)	14 (12.17)	0.8850
Preoperative incontinence			
No	48 (88.89)	103 (89.57)	
Yes	6 (10.91)	12 (10.43)	1
Preoperative urinary retention			
No	37 (68.52)	80 (69.57)	
Yes	17 (31.48)	35 (30.43)	0.8910
History of UTI in the year prior to surgery			
No	40 (74.07)	97 (84.35)	
Yes	14 (25.93)	18 (15.65)	0.1120

HoLAP = holmium laser ablation of the prostate; HoLEP = holmium laser enucleation of the prostate; BMI = body mass index; ASA = American Society of Anesthesiologists; BOOI = bladder outlet obstruction index, PSA = prostate-specific antigen; DRE = digital rectum exam; TRUS = transurethral ultrasound; UTI = urinary tract infection

hypertension, neurological disease, or anticoagulation use. With regard to preoperative prostate characteristics, on digital rectal exam (DRE) prostates in the HoLEP group were estimated, on average, 46.12 g while prostates in the HoLAP group were estimated to be significantly less, at 37.72 (p = 0.0031). Among patients with TRUS measurements (34.3%), mean preoperative volume in the HoLAP group was 48.6 cc (n = 14, range 26 cc -70 cc) compared to 81.06 cc (n = 45, range 27 cc-230 cc) in the HoLEP group (p = 0.0017). Preoperatively, patients in the HoLAP group had lower PSA levels than HoLEP (3.26 ng/dL and 6.30 ng/dL, p = 0.0017). In terms of voiding function, both groups had similar maximum flow rates (Qmax). In the HoLAP group the mean flow rate prior to surgery was 6.59 cc/s, and in the HoLEP group the mean flow rate prior to surgery was 7.22 cc/s (p = 0. 4241). Preoperative bladder obstruction index (BOOI) scores between HoLAP and HoLEP groups were also similar (70.44 and 67.25, p = 0.6528). There were also no differences in the proportions of patients in each group who were taking medications for voiding dysfunction, who had incontinence preoperatively (defined as anyone describing overflow, stress or urge type incontinence requiring at least one pad per day), who had indwelling catheters, or who performed clean intermittent catheterization.

The HoLAP group had a shorter mean operative time than HoLEP by 42 minutes (77 min versus 119 min, p < 0.0001), and required less mean follow up time (27 months versus 38 months, p = 0.0007), Table 2. There were a total of four intraoperative complications that all involved morcellator malfunction. There were no other intraoperative complications in either group. One year after surgery, PSA was similar between groups. Patients in the HoLEP group had better flow rates, with an average Qmax of 16.81 mL/sec versus 13.24 mL/sec in the HoLAP group (p = 0.0438). However, when the net change in flow rate is compared between the two groups, there is no statistical difference. There was also no difference in the net change in PSA values between groups (1.82 versus 2.8, p value 0.15). There were a total of eight reoperations for adenoma regrowth in the time period analyzed. The reoperation rate was 4.7%, and there was no difference in reoperations between groups (1.85% in the HoLAP group and 6.09% HoLEP group). Reoperations were performed for anterior regrowth that was presumed to be underresected at time of surgery, or lateral tissue that projected into the bladder and either was too far to access and/or there was concern regarding bladder resection. Five patients were brought back for hematuria from the residual tissue and three for return of obstructive symptoms. In all cases, the contracted nature of the fossa after previous resection facilitated removal of the remaining tissue.

A subgroup analysis was performed for all patients with glands 60 grams and under to assess if there were any differences between HoLEP and HoLAP in similar sized glands. No differences between groups were found, but the numbers in each group were very small. There were also varying amounts of missing data in each variable, making it difficult to draw any significant conclusions from the findings.

At 30 days, there were no differences between the proportions of patients with complications in either

TABLE 2. **Post-surgical outcomes**

	HoLAP	**HoLEP**	**p value**
Operative time, min (± SD)	76.50 (30.69)	119.33 (48.80)	> 0.0001*
Intraoperative complications (± SD)	0	4	
Postoperative PSA at 1 year (± SD)	1.82 (1.56)	2.80 (3.79)	0.1593
Postoperative Qmax at 6-8 weeks (± SD)	13.24 (5.95)	16.81 (9.00)	0.0438*
Net change in flow	6.02 (7.66)	9.49 (9.82)	0.1145
Net change in PSA	-2.34 (4.49)	-3.64 (4.39)	0.1649
Follow up, in months (± SD)	27.15 (17.48)	38.18 (20.11)	0.0007*
Admitted postop			
No	45 (84.91)	82 (71.93)	
Yes	8 (15.09)	32 (28.07)	0.0670
Reoperation, excluding morcellator malfunction			
No	53 (98.15)	107 (93.04)	
Yes	1 (1.85)	7 (6.09)	0.1680

HoLAP = holmium laser ablation of the prostate; HoLEP = holmium laser enucleation of the prostate; PSA = prostate-specific antigen

TABLE 3. **Complications at 30 days with Clavien classification**

Grade	complication	N
I	Acute urinary retention after catheter removal	11
	Hematuria/clot retention	1
	Incontinence	12
II	Lower urinary tract infection	7
	Deep vein thrombosis	1
IIIa	Stricture	1
	Meatal stenosis	1
IIIb	Remnant chips in bladder	4

TABLE 4. **Complications at 1 year with Clavien classification**

Grade	complication	N
III	Incontinence	5
	Stricture	1
	Peyronie's disease	1
IIIb	Bladder neck contracture	2
	Incontinence (treated surgically with coaptite)	1

group. The overall complication rate at 30 days was 22.5%. At 1 year, the overall complication rate was 5.9%. There was no difference between groups with regard to complications recorded at 1 year. A list of complications at 30 days and at 1 year along with their Clavien classifications are provided in Tables 3 and 4, respectively.

Discussion

Holmium laser is an effective, well-tolerated surgical therapy for treatment of symptomatic BPH. As with all surgery, technique matters. The energy generated by the holmium laser is quickly absorbed by water and water containing tissues and heat is quickly dissipated, particularly within a fluid environment (endourology). This aspect of holmium laser makes it ideal for precise cutting and resection, because it vaporizes tissue with a shallow coagulation zone.[30] In contrast to other laser modalities, holmium laser allows for visualization of the capsule, providing an anatomical endpoint for resection and ablation.

Overall, HoLEP is comparable to TURP and open prostatectomy for moderate to severe LUTS and adenomas of all size, with significantly less blood loss, fewer blood transfusions, and fewer days of catheterization.[12-14,29] That said, there is a significant learning curve associated with HoLEP and early cases are associated with a higher frequency of complications.[15-17,31] From our experience, morcellator malfunctions are the most common intraoperative issue.

In contrast, holmium laser ablation does not require morcellation and is easier to learn. In 2003, Tan et al reported on the 7 year outcomes for a population of patients who had HoLAP between 1994 and 1995 and found that patients treated with 60W lasers had an 83% improvement in Qmax and a 47% reduction in AUA symptom score 7 years later. Reoperation rate was 15% at 7 years.[20] Currently, there are 80W, 100W and 120W lasers available, allowing for ablation of larger prostates. The capability to adjust pulse widths in the 120-watt unit may allow for ablation with shorter operative times, but this has not been studied.

In this study, we compared our outcomes for holmium ablation to enucleation. As would be predicted, HoLAP took less operative time than HoLEP – both because of the lack of morcellation, and the smaller prostate size. Operative times in each group were also comparable to previously published studies.[12,14,20] In contrast, but equally expected, patients undergoing HoLEP had larger prostates and as a result, a larger amount of tissue was resected leading to a larger net change in PSA and greater flow rates in the HoLEP group. There were four morcellation malfunctions in the HoLEP group, all with a previous version of the Versacut morcellator (Lumenis, Inc.). Overall, the reoperation rate was 4.7% at the conclusion of our study period, and rates were similar between groups due to the low numbers. This is an improvement on the reoperation rate noted by Mottett et al after 12 months. Other studies examining reoperation rates over a longer time period have noted reoperation rates between 4.2% and 15%.[20,32,33] With respect to complications, the most common complication in our study at 30 days was temporary stress incontinence (7.1%). At 1 year, 6 patients in the entire cohort (3.5%) reported some element of stress incontinence, only one of whom required surgical management with urethral bulking agent (preoperatively had bladder stones, was on finasteride and terazosin, pathology revealed significant chronic inflammatory change, 40 grams with dimensions 10 cm x 7 cm x 3 cm in loose aggregate). At 30 days, our urethral stricture rate was 0.6% (1 patient) and was the same at 1 year (0.6%, 1 patient). There were two bladder neck contractures (1.1%) requiring surgical management at the end of 1 year. These findings are comparable to a meta-analysis of reported complications among patients who undergo laser enucleation.[34]

With so many options for surgical therapy for BPH, how does a surgeon decide which modality is best? Decisions may not be based simply on what a surgeon desires, but also on economics, hospital/institutional support, and resources. Often, a purchased unit is utilized as the ability to have access to all various modalities is simply not possible or feasible. The truth is, nearly all surgical therapies for BPH lead to excellent outcomes and there is likely no best single approach that can be applied to every prostate, every patient, every situation.

So the answer is this – whatever modality is employed, it should be used correctly, safely, and with the proven general principles of prostate surgery achieved – removal of adenoma to surgical capsule as much as is possible. It is the opinion of the authors that when proper technique is applied, holmium ablation and enucleation should provide similar postoperative results. With complete ablation to the surgical capsule, there is minimal regrowth of adenoma and reoperative rates should be no different than techniques employing removal of adenoma directly from the level of the surgical capsule. When proper principles are followed patients have predictable outcomes. Therefore, it is imperative that surgeons choosing a "surface to capsule" approach make every attempt to attain capsule in the majority of their treatment site.

This study had several limitations. First, this is a series of cases taken from the caseload of a single surgeon at a VA hospital. Residents were involved to varying degrees in all cases, which could impact the operative time. The results of this study may not be generalizable to other populations of patients, or to the experiences of other surgeons. Second, this was not a randomized, controlled trial. As patients were selected for either surgery based on their perioperative anatomy, they were not matched according to prostate size, BOOI, age, or BMI.

Conclusions

There is no shortage of surgical modalities for the management of BPH. Laser therapies are abundant, each with its own set of favorable and limiting characteristics. The holmium wavelength is particularly well suited for prostate surgery and can be used in patients with all prostate sizes. Despite this, a steep learning curve and need for morcellation are barriers to adaptation of HoLEP. HoLAP, however, requires no morcellator and is easy to learn. This study suggests that when performed correctly (ablation to capsule), HoLAP produces similar results to HoLEP. Whether a surgeon performs enucleation versus ablation, technique is important and above all else, surgeons should attempt to attain capsule with whatever approach they employ. □

References

1. Girman CJ, Jacobsen SJ, Guess HA et al. Natural history of prostatism: relationship among symptoms, prostate volume and peak urinary flow rate. *J Urol* 1995;153(5):1510-1515.
2. DuBeau CE. The aging lower urinary tract. *J Urol* 2006;175(3 Pt 2): S11-S15.
3. Berry SJ, Coffey DS, Walsh PC et al. The development of human benign prostatic hyperplasia with age. *J Urol* 1984;132(3):474-479.
4. Kok ET, Schouten BW, Bohnen AM et al. Risk factors for lower urinary tract symptoms suggestive of benign prostatic hyperplasia in a community based population of healthy aging men: the Krimpen Study. *J Urol* 2009;181(2):710-716.
5. Chughtai B, Lee R, Te A, Kaplan S. Role of inflammation in benign prostatic hyperplasia. *Rev Urol* 2011;13(3):147-150.
6. Peters CA, Walsh PC. The effect of nafarelin acetate, a luteinizing-hormone–releasing hormone agonist, on benign prostatic hyperplasia. *N Engl J Med* 1987;317(10):599-604.
7. Berger AP, Deibl M, Leonhartsberger N et al. Vascular damage as a risk factor for benign prostatic hyperplasia and erectile dysfunction. *BJU Int* 2005;96(7):1073-1078.
8. Madersbacher S, Marszalek M, Lackner J et al. The long-term outcome of medical therapy for BPH. *Eur Urol* 2007;51(6): 1522-1533.
9. Gilling PJ, Cass CB, Cresswell MD et al. The use of the holmium laser in the treatment of benign prostatic hyperplasia. *J Endourol* 1996;10(5):459-461.
10. Hoekstra RJ, Van Melick HHE, Kok ET et al. A 10-year follow-up after transurethral resection of the prostate, contact laser prostatectomy and electrovaporization in men with benign prostatic hyperplasia; long-term results of a randomized controlled trial. *BJU Int* 2010;106(6):822-826.
11. Sarica K, Alkan E, Lüleci H et al. Photoselective vaporization of the enlarged prostate with KTP laser: long-term results in 240 patients. *J Endourol* 2005;19(10):1199-1202.
12. Tan AHH, Gilling PJ, Kennett KM et al. A randomized trial comparing holmium laser enucleation of the prostate with transurethral resection of the prostate for the treatment of bladder outlet obstruction secondary to benign prostatic hyperplasia in large glands (40 to 200 grams). *J Urol* 2003;170 (4 Pt 1):1270-1274.
13. Westenberg A, Gilling P, Kennett K et al. Holmium laser resection of the prostate versus transurethral resection of the prostate: results of a randomized trial with 4-year minimum long-term followup. *J Urol* 2004;172(2):616-619.
14. Wilson LC, Gilling PJ, Williams A et al. A randomised trial comparing holmium laser enucleation versus transurethral resection in the treatment of prostates larger than 40 grams: results at 2 years. *Eur Urol* 2006;50(3):569-573.
15. Seki N, Mochida O, Kinukawa N et al. Holmium laser enucleation for prostatic adenoma: analysis of learning curve over the course of 70 consecutive cases. *J Urol* 2003;170(5):1847-1850.
16. Robert G, Cornu J-N, Fourmarier M et al. Multicenter prospective evaluation of the learning curve of the holmium laser enucleation of the prostate (HoLEP). *BJU Int* 2016;117(3):495-499.
17. Placer J, Gelabert-Mas A, Vallmanya F et al. Holmium laser enucleation of prostate: outcome and complications of self-taught learning curve. *Urology* 2009;73(5):1042-1048.
18. Barski D, Richter M, Winter C et al. Holmium laser ablation of the prostate (HoLAP): intermediate-term results of 144 patients. *World J Urol* 2013;31(5):1253-1259.
19. Kumar SM. Rapid communication: holmium laser ablation of large prostate glands: an endourologic alternative to open prostatectomy. *J Endourol* 2007;21(6):659-662.
20. Tan AHH, Gilling PJ, Kennett KM et al. Long-term results of high-power holmium laser vaporization (ablation) of the prostate. *BJU Int* 2003;92(7):707-709.

21. Malek RS, Kuntzman RS, Barrett DM. High power potassium-titanyl-phosphate laser vaporization prostatectomy. *J Urol* 2000; 163(6):1730-1733.
22. Gilling PJ, Cass CB, Malcolm AR et al. Combination holmium and Nd:YAG laser ablation of the prostate: initial clinical experience. *J Endourol* 1995;9(2):151-153.
23. Tan AHH, Gilling PJ. Holmium laser prostatectomy: current techniques. *Urology* 2002;60(1):152-156.
24. Lerner LB, Shirk J, Nimeh T. Holmium ablation of prostate. In: Treatment of benign prostatic hyperplasia: modern alternative to transurethral resection of the prostate. Edited by B Chungtai, AE Te and SA Kaplan. New York: Springer Science + Business Media 2015; pp 49-59.
25. Roehrborn CG, Boyle P, Gould AL et al. Serum prostate-specific antigen as a predictor of prostate volume in men with benign prostatic hyperplasia. *Urology* 1999;53(3):581-589.
26. Lim KB, Ho H, Foo KT et al. Comparison of intravesical prostatic protrusion, prostate volume and serum prostatic-specific antigen in the evaluation of bladder outlet obstruction. *Int J Urol* 2006;13(12):1509-1513.
27. Mamoulakis C, Efthimiou I, Kazoulis S et al. The modified Clavien classification system: a standardized platform for reporting complications in transurethral resection of the prostate. *World J Urol* 2011;29(2):205-210.
28. Choi JI, Moon KY, Yoon JH et al. Application of the modified Clavien classification system to 402 cases of holmium laser enucleation of the prostate for benign prostatic hyperplasia. *Korean J Urol* 2014;55(3):178-181.
29. StataCorp. Stata Statistical Software. College Station, TX: StataCorp LP; 2013.
30. Gravas S, Bachmann A, Reich O et al. Critical review of lasers in benign prostatic hyperplasia (BPH). *BJU Int* 2011;107(7):1030-1043.
31. Lerner LB, Tyson MD, Mendoza PJ. Stress incontinence during the learning curve of holmium laser enucleation of the prostate. *J Endourol* 2010;24(10):1655-1658.
32. Mottet N, Anidjar M, Bourdon O et al. Randomized comparison of transurethral electroresection and holmium: YAG laser vaporization for symptomatic benign prostatic hyperplasia. *J Endourol* 1999;13(2):127-130.
33. Elzayat EA, Elhilali MM. Holmium laser enucleation of the prostate (HoLEP): long-term results, reoperation rate, and possible impact of the learning curve. *Eur Urol* 2007;52(5):1465-1471.
34. Yin L, Teng J, Huang C-J et al. Holmium laser enucleation of the prostate versus transurethral resection of the prostate: a systematic review and meta-analysis of randomized controlled trials. *J Endourol* 2013;27(5):604-611.