# *A retrospective comparison of diode to holmium for laser enucleation of the prostate*

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***Introduction:*** *Holmium endoscopic laser enucleation of the prostate (HoLEP) is a well-established alternative to traditional transurethral resection and open prostatectomy for the treatment of benign prostatic hyperplasia (BPH). We investigate the 1470 nm diode laser for enucleation as an alternative to HoLEP. The safety, efficacy, and initial outcomes of diode enucleation of the prostate (DiLEP), when compared to HoLEP, were examined.*

***Materials and methods:*** *We reviewed records of 50 patients who underwent DiLEP between 2012 and 2015 and matched them with 50 HoLEP patients during the same time period. Objective evaluation of efficacy was determined by comparing preoperative post-void residual volume (PVR) and peak flow (Qmax) to postoperative values at 4-16 weeks and 1 year following surgery. Subjective evaluation was measured using the International Prostate Symptom Score (IPSS) before and after the operation. Safety was evaluated by the development of persistent Clavien-Dindo grade 1, or 2 or higher postoperative complications. Statistical analyses were conducted using chi-squared and paired Student's t-tests.*

***Results:*** *Subjective and objective postoperative results showed no difference between DiLEP and HoLEP. Average PVR volume following DiLEP was 47.1 mL at 1 year. The mean increase in Qmax was 16.4 mL/s at 1 year. The IPSS improved by a mean of 12.7 points, and by 2.6 points on quality of life questioning at 1 year post operation. Compared to HoLEP patients there was no statistically significant difference. Safety assessments were the same across both procedures.*

***Conclusions:*** *Diode laser is safe and effective for use in patients with BPH, with no significant difference in outcomes compared to HoLEP.*

**Key Words:** BPH, laser, enucleation, diode, HoLEP

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## Introduction

Our study examines the use of a newer laser for treatment of benign prostatic hyperplasia (BPH). BPH is a common condition affecting many men over the age of 50, with almost 80% of men greater than 70 affected.[1] BPH is

caused by unregulated proliferation within the prostatic transition zone, which can cause physical compression of the urethra and result in anatomic bladder outlet obstruction (BOO).[2] Recently there has been a rise of newer modalities to treat BPH, including laser enucleation.[3] Holmium:Ytrium Alumnium Garnet laser (Ho:YAG, holmium), with a wavelength of 2140 nm, was adopted for use on soft-tissue within the lower urinary tract, more specifically for BPH.[4,5] In a procedure termed Holmium Laser Enucleation of the Prostate (HoLEP) the adenoma is enucleated off the surgical capsule into the bladder before removal with an endoscopic removal device (Transurethral Soft-tissue Morcellator). This is an endoscopic equivalent to an open simple prostatectomy. HoLEP has proven to be more efficacious than TURP with improved outcomes such as; better short term efficacy, fewer immediate complications, and shorter hospital stays.[6-8] Critically, these results are seen regardless or patients age, or prostate size.[9-11] With this, the revised AUA guidelines on BPH states that laser enucleation, with either holmium or thulium, are the only minimally invasive treatment options for BPH that is prostate size independent.[12] As we continue to explore the use of new lasers, beyond holmium, for usage in the lower urinary tract, we attempted to identify the diode laser as a safe and effective laser to be used as an alternative for prostate reducing procedures.

In this study we propose the use of a 1470 nm wavelength diode laser for enucleation of prostatic adenoma (DiLEP). Due to the paucity of research investigating this laser, little is known about its efficacy. We aim to assess objective and subjective outcomes of the DiLEP patients relative to HoLEP patients, as well as establish the safety and efficacy in patients demonstrating BOO. In doing so we hope to uncover a viable alternative for prostate enucleation, which may be more user friendly than the holmium laser.

## Materials and methods

An Institutional Review Board (IRB) approved retrospective chart review was completed of 50 patients who underwent DiLEP between May 2012 and December 2015. Patients were chosen at random and based on laser availability. Blood thinners were stopped before the procedure, allowing the appropriate amount of time required for return to normal coagulation. Patients on aspirin were allowed to continue with their current regimen. Patients who were found to be actively bleeding on cystoscopy were excluded from the study. DiLEP was performed using the T-1470 ProTouch 1470 nm diode laser (Convergent Laser Technologies, Alameda, CA, USA). Optimal energy setting for cutting to perform enucleation is 65 watts based on surgeon experience. We used an end-firing 600 micron laser fiber to avoid potential increase in laser energy absorption. The enucleation and morcellation steps of the DiLEP procedure are identical to the standard HoLEP procedure described in previous work.[13] Like HoLEP, the surgical endpoint of the DiLEP procedure is the complete enucleation of the prostatic adenoma off the surgical capsule. Adenoma was retrieved via foreign body graspers (for small pieces) or endoscopically using a transurethral soft-tissue morcellator through an offset nephroscope. The specimens collected were sent for pathologic evaluation.

All patients were de-identified according to IRB guidelines. Demographic data was captured including preoperative and postoperative parameters; peak urinary flow (Qmax) (mL/s; milliliters per second) and voided volume measured (mL; milliliters) were measured using an office based uroflowmetry system. Preoperative and postoperative post void residual (PVR) volume (mL) was measured using an ultrasound bladder scanner. Prostate volume was measured (mL) either by computerized tomography or transrectal ultrasound. Patients underwent urodynamic testing (Laborie Medical Technologies) prior to DiLEP, confirming BOO based on urodynamic results showing low flow and high contractility, while patients showing low flow and low contractility required further work up for BOO confirmation. Postoperative parameters were measured at a postoperative visit at 4-16 weeks and again at 1 year. As a control, we utilized a group of 50 patients receiving HoLEP during the same time period by the same surgeon, using the same technique.

Subjective evaluation of patient symptoms were assessed using the International Prostate Symptom Score (IPSS), a validated questionnaire that includes 7 symptom questions each involving an assignment of symptom severity from 0 to 5 for a total of maximum 35 points. The 8$^{th}$ question evaluates quality of life (QoL) with the question "If you were to spend the rest of your life with your urinary condition just the way it is now, how would you feel about that?" Patients choose from 1 (delighted) to 7 (terrible). Other data captured included duration of procedure, length of foley catheterization after the procedure, and hospital length of stay. Statistical analyses were completed using paired Student's t-tests and chi-squared, with significance at $p < 0.05$.

Safety of the DiLEP procedure was assessed using the Clavien-Dindo system.[14] We screened the records for any adverse events that were possibly, probably, or definitely related to the surgical procedure which were Clavien-Dindo grade 2 or higher. We also assessed each participant for Grade 1 adverse events

that persisted beyond 2 postoperative visits, such as urinary dysfunction.

## Results

Table 1 highlights key demographic data, baseline preoperative and postoperative characteristics between the two groups. There was no significant differences in preoperative baseline characteristics between the two cohorts. Perioperative characteristics and 1 year postoperative data was also not significantly different between the two groups, Table 1. No patients were lost to follow up. Operative times on average were longer in the HoLEP group, though not significantly (p = 0.5113). Additionally, DiLEP patients had an average hospital stay of 1.5 days. Foley catheters were removed postoperatively after an average of 2.7 days, with 66.7% removed on day 1. With regards to postoperative characteristics, the PVR volume in the DiLEP patients was lowered to a mean of 47.1 mL, compared to a PVR of 47.4 mL in the HoLEP patients (p = 0.9846). The median PVR in the DiLEP group was 21.5 mL, compared to 30.0 mL in the HoLEP group. The mean IPSS results improved across both patients groups, with DiLEP patients to 5.6 and HoLEP patients to 5.1 (p = 0.6902). QoL scoring from the IPSS questionnaire had improved to 1.3 and 0.8 (p = 0.1151) in the DiLEP and HoLEP groups, respectively.

Data were collected from both groups at 4-16 week postoperative follow up to the 1 year follow up, Table 2. At 4-16 weeks, the total IPSS decreased to a mean of 10.5 points while the QoL score improved by 1.8 points for DiLEP patients, while improving to 7.3 and 1.5 respectively in HoLEP patients. The 1 year follow up results showed continuous and durable improvement in both cohorts for PVR, Qmax and IPSS scores.

TABLE 1. **Baseline and preoperative testing results. Perioperative and postoperative statistics in DiLEP and HoLEP patients at 1 year after operation. All results shown are mean ± standard deviation**

| | **DiLEP patients (n = 50)** | **HoLEP patients (n = 50)** | **p value** |
|---|---|---|---|
| **Preoperative testing** | | | |
| Age | 71.5 ± 9.7 | 71.2 ± 8.0 | 0.8787 |
| Body mass index | 28.4 ± 4.6 | 28.6 ± 4.8 | 0.8931 |
| Serum PSA (ng/mL) | 5.8 ± 8.9 | 5.4 ± 4.3 | 0.8416 |
| Catheter dependence (%) | 32% | 34% | 0.8316 |
| TRUS prostate size (mL) | 89.5 ± 51.3 | 116.0 ± 72.0 | 0.1605 |
| Preop uroflow peak flow (mL/s) | 8.5 ± 9.3 | 6.7 ± 6.4 | 0.3504 |
| Preop uroflow mean flow (mL/s) | 4.5 ± 2.6 | 3.2 ± 2.3 | 0.1431 |
| Preop post void residual (mL) | 360.5 ± 335.9 | 296.9 ± 265.9 | 0.3639 |
| Preop IPSS results | 18.3 ± 9.6 | 18.0 ± 9.6 | 0.9015 |
| Preop IPSS QoL results | 3.9 ± 0.9 | 3.5 ± 1.2 | 0.2316 |
| **Perioperative testing** | | | |
| Laser energy used (kJ) | 307.9 ± 191.9 | 295.2 ± 125.7 | 0.7980 |
| Operative time (min) | 125.2 ± 70.1 | 147 ± 76.4 | 0.5113 |
| **Postoperative testing** | | | |
| Catheterization (days) | 2.7 ± 2.3 | 2.7 ± 2.9 | 0.9525 |
| Postopp uroflow peak flow (mL/s) | 24.9 ± 14.2 | 27.4 ± 18.3 | 0.5068 |
| Postopp uroflow mean flow (mL/s) | 6.3 ± 3.0 | 7.1 ± 4.9 | 0.4518 |
| Postop post void residual (mL) | 47.1 ± 72.0 | 47.4 ± 54.0 | 0.9846 |
| Postop IPSS results | 5.6 ± 3.9 | 5.1 ± 4.0 | 0.6902 |
| Postop IPSS QoL results | 1.3 ± 0.9 | 0.8 ± 1.3 | 0.1151 |

PSA = prostate-specific antigen; TRUS = transrectal ultrasound; IPSS = International Prostate Symptom Score

TABLE 2. **Subjective outcomes at 4-16 week follow up and 1 year follow up using International Prostate Symptom Score (IPSS) and International Prostate Quality of Life. Results shown are averages**

| | | DiLEP (n = 50) | |
|---|---|---|---|
| | **Preop** | **4-16 week result** | **12 months result** |
| Post void residual (mL) | 360.5 | 51.3 | 47.1 |
| Peak uroflow rate (mL/s) | 8.5 | 19.7 | 24.9 |
| IP symptom score | 18.3 | 10.5 | 5.6 |
| IPSS quality of life | 3.9 | 2.1 | 1.3 |
| | | **HoLEP (n = 50)** | |
| | **Preop** | **4-16 week result** | **12 months result** |
| Post void residual (mL) | 360.5 | 88.1 | 47.4 |
| Peak uroflow rate (mL/s) | 8.5 | 18.2 | 27.4 |
| IP symptom score | 18.3 | 7.3 | 5.1 |
| IPSS quality of life | 3.9 | 1.5 | 0.8 |

Complication rates, according to the Clavien-Dindo grading system, are reported in Table 3. Overall complication rates were not significantly different between groups (DiLEP 18 events, HoLEP 22 events, p = 0.4142). There was no difference observed in any of the assessed complications for Grade 1-4 complications. There was no reported Grade 5 complications. Reoperation rates for the DiLEP and HoLEP was 6% and 14%, respectively (p = 0.1824). Moreover, 2 (29%) of the 7 patients requiring reoperation from the HoLEP group underwent more than one additional prostate reducing procedure. Reoperations occurred at an average of 43.7 months for the DiLEP procedure and at an average of 27.0 months for the HoLEP procedure. Our data indicate that there is no significant difference in re-operation rates.

TABLE 3. **Safety outcomes in patients using the Clavien-Dindo grading scale. Grade 3A and 3B were combined. No Grade 5 complications occurred**

| **Clavien-Dindo Grade** | **DiLEP (n = 50)** | **HoLEP (n = 50)** | **p value** |
|---|---|---|---|
| **Grade 1** | | | |
| Re-catheterization | 3 | 3 | 1.000 |
| Clot retention | 2 | 2 | 1.000 |
| Urinary incontinence | 5 | 4 | 0.7268 |
| **Grade 2** | | | |
| Blood transfusions | 0 | 0 | 1.000 |
| Pain | 3 | 5 | 0.4610 |
| Urinary tract infection | 3 | 4 | 0.6951 |
| **Grade 3 (A & B)** | | | |
| Urethral strictures | 2 | 3 | 0.3997 |
| Bleeding | 0 | 0 | 1.000 |
| **Grade 4** | | | |
| Myocardial infarction | 0 | 1 | 1.000 |

## Discussion

Being one of very few studies looking at 1470 nm wavelength lasers, our goal was to evaluate the objective and subjective outcomes, and to assess the 1 year durability of the DiLEP when compared to the HoLEP procedure. Our data indicated that the DiLEP procedure is safe and effective for treating men with BPH. We propose the use of a 1470 nm diode as a safe and feasible alternative to the better known HoLEP technique. This laser was selected due to its high water absorption coefficient, similar to the holmium laser, and hemostatic properties. The successful hemostasis at this wavelength is due to its rapid absorption by oxyhemoglobin, which is greater than the 2140 nm holmium laser. This allows for controlled tissue cutting with limited blood loss in our experience.

The "diode laser" is not a unique laser, but rather is a grouping of lasers, all of which use a different semiconductor bar. By altering the type of bar utilized, these lasers are able to generate a variety of different wavelengths. As all of these lasers have different wavelengths, they should be studied independently. Here, a 1470 nm wavelength was evaluated by using the Convergent T1470 diode laser. This was selected due to its favorable profile for soft tissue cutting. This particular wavelength has intriguing properties including high absorption by water and hemoglobin, which make this wavelength ideal for ablating soft tissue such as the prostate.[15] When compared to the holmium laser, this wavelength has a similarly high water absorption coefficient, but is better absorbed by oxyhemoglobin. It is thought that this high absorption by oxyhemoglobin is what leads to effective coagulation. Critically, studies have shown that the ablative properties of the diode laser are superior to holmium and comparable to potassium titanyl phosphate (KTP) lasers.[16] Altogether, these properties elucidate why this laser is an ideal candidate for BPH procedures, like prostate enucleation.

Diode laser usage in the prostate has been limited to this point. Our search of the literature returned multiple studies looking at diode lasers for use in photoselective vaporization of the prostate.[17-19] All of these studies utilized the 980 nm wavelength diode laser for their studies. When looking at the literature on diode enucleation, again the 980 nm wavelength laser seems to be preferred, though the results are promising. These studies outline the safety of the 980 nm diode laser for use in enucleation, as well as prospectively comparing DiLEP to plasmakinetic enucleation and resection of the prostate.[20-22] More recent publications have looked at follow up data from 12 months after treatment, and again found this technique to be non-inferior to bipolar endoscopic enucleation, with decreased risk of hemorrhage, catheterization times, and decreased the length of hospital stay.[23,24] With regards to the 1470 nm wavelength diode laser, one recent publication compared prostate enucleation with this laser to bipolar resection.[25] This prospective study found that the 1470 nm diode laser is similar in efficacy and safety to bipolar resection, with improvements in bleeding, catheterization time, and hospital length of stay, much like the HoLEP technique. The study also followed results up to 12 months and found both objective and subjective improvements in symptoms to be stable over time, and similar to the results of bipolar resection cohort.

There are additional benefits of the diode laser beyond hemostasis. Of note, the Convergent T1470 diode laser is contained within a box weighing only 55 lbs. For comparison, the box from Lumenis for the HoLEP procedure weighs over 400 lbs. This small box allows for previously unavailable portability. The system also utilizes a 110 volt current for power, therefore not requiring an adapter like most other lasers which work on 220-240 volt current. This lack of adapter allows for increased cost savings and makes the diode laser more easily utilized in various settings. Its portability allows for possible use of this laser in an outpatient setting to relieve LUTS from BPH. The future possibility of avoiding a trip to the hospital is of significant interest due to patient satisfaction. Previous research has shown that over 80% of patients preferred procedures in-office over the hospital when given the choice.[26] This is one of the reasons why this laser piqued our interest, and why we feel it could play a critical role in urological care of BPH moving forward.

With regards to objective outcomes, our DiLEP results are comparable to both our own HoLEP results and published HoLEP results. Sun et al performed a randomized clinical trial evaluating HoLEP patients at 1 and 12 months postoperatively.[27] They reported their patients had a mean hospital stay of 1 day and catheterization time of 2 days. They show Qmax improvements by 13.1 mL/s and 14.5 mL/s at 1 and 12 months, respectively. These results are also similar to those found by Krambeck et al, in their study of over 1,000 HoLEP patients.[8] Postoperative PVR also improved by 100 mL and 103 mL at 1 and 12 months, respectively. The change they found from 1 to 12 months is consistent with our findings. It is notable that overall our results are in line with other reported outcomes. Our slightly more robust outcomes for Qmax and PVR after DiLEP compare favorably with short and long term outcomes of HoLEP.

For subjective outcomes, we analyzed patient's responses to QoL questioning from the IPSS survey. Our patients began with a QoL index of 3.9, meaning they would feel mixed to mostly dissatisfied on average if they had to spend the rest of their lives in their current state. This concurs with previously published data showing BPH has a negative impact on QoL.[28-31] One year after undergoing the DiLEP procedure, patient's responses improved to an average of 1.3, stating they would be pleased to mostly satisfied with current results. These results show that the objective outcomes seen also correlate to a significant positive impact in subjective findings.

Also compelling is the difference in reoperation rates we encountered, which were assessed with no upper time limit. While not statistically significant, there were more than double the number of patients requiring further prostate reducing surgeries in the HoLEP compared to the DiLEP group, with two patients requiring more than one procedure. In addition, the time elapsed between surgery and reoperation also favors the long term durability of the DiLEP procedure in comparison to the HoLEP. This helps highlight the possibility of greater long term durability with DiLEP as compared to HoLEP, though this requires further investigation.

While our results show the feasibility of this laser, we do recognize some difficulties with this laser, particularly when compared to its holmium counterpart. Significantly, we found it was more difficult to identify the surgical capsule during the procedure while using this laser compared to holmium. The 1470 nm diode laser's increased depth of penetration may lead to increased thermal injury.[16] Due to these findings, it is likely that the 1470 nm diode laser would not replace the holmium laser, but instead function as an alternative, or potentially as an outpatient option. Finally, postoperative sexual dysfunction after DiLEP should be assessed with standardized questionnaires to ascertain its effect on sexual function.

Our study is not without limitations. Our study provides a retrospective review of the procedure, which has its inherent limitations. Though the preliminary data presented here looks encouraging, a prospective, randomized control trial comparing DiLEP to HoLEP and other endoscopic procedures such as TURP would be ideal for evaluating effectiveness. Besides that, although we subjectively felt as though the diode laser provided excellent hemostasis, we were unable to compare this to HoLEP using pre to postoperative hemoglobin changes, which is needed to help verify this claim. This was not possible as most patients were admitted for 23 hours and had no blood testing performed after the procedure.

## Conclusions

Our results show that this laser presents an important possible alternative to the more widely accepted holmium laser for use in prostate enucleation. This laser has many properties that make its use intriguing, such as cost and portability. Our study demonstrates the feasibility of DiLEP as a safe and effective alternative in the endoscopic surgical management of BPH. Further studies, including randomized control trials, comparing direct outcomes of DiLEP to HoLEP, and other newer procedures, will be needed to support the potential use of DiLEP as an important surgical option in the future.

## Disclosures

Akhil Das is a consultant for Lumenis and Convergent. Patrick Shenot is an investigator with financial support from Ipsen, and a consultant for Merck. Seth Teplitsky, Alex Uhr, Joon Yau Leong, and Victor Kucherov have no conflicts of interest to declare. □

References


1. Wei JT, Calhoun E, Jacobsen SJ. Urologic diseases in America project: benign prostatic hyperplasia. *J Urol* 2005;173(4):1256-1261.
2. Patel ND, Parsons JK. Epidemiology and etiology of benign prostatic hyperplasia and bladder outlet obstruction. *Indian J Urol* 2014;30(2):170-176.
3. Zarrabi A, Gross AJ. The evolution of lasers in urology. *Ther Adv Urol* 2011;3(2):81-89.
4. Fraundorfer MR, Gilling PJ. Holmium:YAG laser enucleation of the prostate combined with mechanical morcellation: preliminary results. *Eur Urol* 1998;33(1):69-72.
5. Gilling PJ, Kennett K, Das AK, Thompson D, Fraundorfer MR. Holmium laser enucleation of the prostate (HoLEP) combined with transurethral tissue morcellation: an update on the early clinical experience. *J Endourol* 1998;12(5):457-459.
6. Michalak J, Tzou D, Funk J. HoLEP: the gold standard for the surgical management of BPH in the 21(st) Century. *Am J Clin Exp Urol* 2015;3(1):36-42.
7. Cornu JN, Ahyai S, Bachmann A et al. A systematic review and meta-analysis of functional outcomes and complications following transurethral procedures for lower urinary tract symptoms resulting from benign prostatic obstruction: an update. *Eur Urol* 2015;67(6):1066-1096.
8. Krambeck AE, Handa SE, Lingeman JE. Experience with more than 1,000 holmium laser prostate enucleations for benign prostatic hyperplasia. *J Urol* 2013;189(1 Suppl):S141-S145.
9. Krambeck AE, Handa SE, Lingeman JE. Holmium laser enucleation of the prostate for prostates larger than 175 grams. *J Endourol* 2010;24(3):433-437.
10. Mmeje CO, Nunez-Nateras R, Warner JN, Humphreys MR. Age-stratified outcomes of holmium laser enucleation of the prostate. *BJU Int* 2013;112(7):982-989.

11. Humphreys MR, Miller NL, Handa SE, Terry C, Munch LC, Lingeman JE. Holmium laser enucleation of the prostate--outcomes independent of prostate size? *J Urol* 2008;180(6):2431-2435; discussion 2435.
12. Foster HE, Barry MJ, Dahm P et al. Surgical management of lower urinary tract symptoms attributed to benign prostatic hyperplasia: AUA guideline. *J Urol* 2018;200(3):612-619.
13. Kelly DC, Das A. Holmium laser enucleation of the prostate technique for benign prostatic hyperplasia. *Can J Urol* 2012;19(1): 6131-6134.
14. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240(2):205-213.
15. Bach T, Muschter R, Sroka R et al. Laser treatment of benign prostatic obstruction: basics and physical differences. *Eur Urol* 2012;61(2):317-325.
16. Seitz M, Ruszat R, Bayer T et al. Ex vivo and in vivo investigations of the novel 1,470 nm diode laser for potential treatment of benign prostatic enlargement. *Lasers Med Sci* 2009;24(3):419-424.
17. Pillai RG, Al Naieb Z, Angamuthu S, Mundackal T. Diode laser vaporisation of the prostate vs. diode laser under cold irrigation: A randomised control trial. *Arab J Urol* 2014;12(4):245-250.
18. Razzaghi MR, Mazloomfard MM, Mokhtarpour H, Moeini A. Diode laser (980 nm) vaporization in comparison with transurethral resection of the prostate for benign prostatic hyperplasia: randomized clinical trial with 2-year follow-up. *Urology* 2014;84(3):526-532.
19. Tan X, Zhang X, Li D et al. Transurethral vaporesection of prostate: diode laser or thulium laser? *Lasers Med Sci* 2018;33(4):891-897.
20. Yang SS, Hsieh CH, Lee YS, Chang SJ. Diode laser (980 nm) enucleation of the prostate: a promising alternative to transurethral resection of the prostate. *Lasers Med Sci* 2013;28(2): 353-360.
21. Xu A, Zou Y, Li, B et al. A randomized trial comparing diode laser enucleation of the prostate with plasmakinetic enucleation and resection of the prostate for the treatment of benign prostatic hyperplasia. *J Endourol* 2013;27(10):1254-1260.
22. Buisan O, Saladie JM, Ruiz JM, Bernal S, Bayona S, Ibarz L. [Diode laser enucleation of the prostate (Dilep): technique and initial results]. *Actas Urol Esp* 2011;35(1):37-41.
23. Wu G, Hong Z, Li C, Bian, C, Huang S, Wu D. A comparative study of diode laser and plasmakinetic in transurethral enucleation of the prostate for treating large volume benign prostatic hyperplasia: a randomized clinical trial with 12-month follow-up. *Lasers Med Sci* 2016;31(4):599-604.
24. Zou Z, Xu A, Zheng S et al. Dual-centre randomized-controlled trial comparing transurethral endoscopic enucleation of the prostate using diode laser vs. bipolar plasmakinetic for the treatment of LUTS secondary of benign prostate obstruction: 1-year follow-up results. *World J Urol* 2018;36(7):1117-1126.
25. Zhang J, Wang X, Zhang Y, Shi C, Tu M, Shi G. 1470 nm diode laser enucleation vs plasmakinetic resection of the prostate for benign prostatic hyperplasia: a randomized study. *J Endourol* 2019;33(3):211-217.
26. Cooper NA, Middleton L, Smith P et al. A patient-preference cohort study of office versus inpatient uterine polyp treatment for abnormal uterine bleeding. *Gynecol Surg* 2016;13(4):313-322.
27. Sun N, Fu Y, Tian T et al. Holmium laser enucleation of the prostate versus transurethral resection of the prostate: a randomized clinical trial. *Int Urol Nephrol* 2014;46(7):1277-1282.
28. Trueman P, Hood SC, Nayak US, Mrazek MF. Prevalence of lower urinary tract symptoms and self-reported diagnosed 'benign prostatic hyperplasia', and their effect on quality of life in a community-based survey of men in the UK. *BJU Int* 1999;83(4):410-415.
29. Peters TJ, Donovan JL, Kay HE et al. The International Continence Society "benign prostatic hyperplasia" study: the botherosomeness of urinary symptoms. *J Urol* 1997;157(3):885-889.
30. Eckhardt MD, van Venrooij GE, van Melick HH, Boon TA. Prevalence and bothersomeness of lower urinary tract symptoms in benign prostatic hyperplasia and their impact on well-being. *J Urol* 2001;166(2):563-568.
31. Castro-Díaz D, Díaz-Cuervo H, Pérez M. [Benign prostatic hyperplasia and its treatment: impact on quality of life and sexual function]. *Actas Urol Esp* 2013;37(4):233-241.