Laser prostate enucleation techniques

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Introduction: *Laser treatment of benign prostatic hyperplasia (BPH) through enucleation techniques has become increasingly more utilized in the field of urology. Laser enucleation of the prostate (LEP) is a transurethral procedure that employs several different types of lasers to dissect the adenoma from the surgical capsule in a retrograde fashion.*

Materials and methods: *We review basic laser physics and current laser prostate enucleation techniques. Holmium-LEP (HoLEP), Thulium-LEP (ThuLEP), Greenlight-LEP (GreenLEP) and Diode-LEP (DiLEP) applications are discussed. We summarize the current literature with respect to functional outcomes and complications.*

Results: *Although each laser device used for prostate enucleation has the same goal of removal of the adenoma from the surgical capsule, each has unique characteristics (i.e. wavelength, absorption rates) that must be understood by the practicing surgeon. Mastery of one LEP technique does not necessarily translate into facile use of an alternative enucleation energy source and/or approach. The various LEP techniques have demonstrated similar, if not superior, postoperative results to transurethral resection of the prostate (TURP), the current gold standard in the treatment of BPH.*

Conclusions: *This article outlines the current LEP techniques and should serve as a quick reference for the practicing urologist.*

Key Words: prostate, laser, surgery, BPH, HoLEP, ThuLEP, GreenLEP, DiLEP

Introduction

Back in the day before transurethral prostate surgery, patients with symptomatic benign prostatic hyperplasia (BPH) underwent open surgery with removal of adenoma along the surgical capsule using a finger. This plane between the central zone and peripheral zone was identified as the surgical margin and even then, it was known that for patients to do well, all the adenomatous tissue required removal. Transurethral resection of the prostate (TURP), while initially a rather morbid procedure fraught with complications, was revolutionary in proving that resection could be performed through a cystoscope, with the majority of the adenoma being removed as close to the surgical capsule as was safe to do. Open surgery was kept only to those patients with large glands too big to resect transurethrally. Over the last 15 years, urologists have taken it another step further, proving that true enucleation of the adenoma, like was done with open surgery, was possible endoscopically. Development of surgical energies that could allow enucleation similar to open prostatectomy led to the first procedure, Holmium Laser Enucleation of the Prostate (HoLEP). Developed and championed by Drs. Peter Gilling and Mark Fraundorfer, HoLEP challenged the reigning

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gold standard, TURP.[1] Once proven that endoscopic prostatic enucleation was possible, it was just a matter of time before the ingenuity of surgeons would lead to the creation of other approaches, utilizing various laser wavelengths, bipolar energy, electrocautery, and even the cold knife.

Multiple energy sources and enucleation techniques have now been described. Lasers such as holmium, thulium, potassium titanyl phosphate (KTP) and diode have all had their respective followings. There are similarities between the surgical approaches employed using these laser wavelengths, but different tissue interactions make it necessary for some variations to exist. Surgeons familiar with one wavelength and approach cannot necessarily employ the same approach with another laser without putting the patient at risk for injury. Above all else, surgeons must understand basic laser physics in order to use each laser safely and achieve the outcome desired. In this article, the most commonly employed laser enucleation approaches will be reviewed, along with important characteristics of each wavelength, and supporting data with outcomes.

Important laser interactions

Physics was already discussed in a previous article, but several points are worth reiterating and deserve emphasis. Medical lasers currently on the market differ in the way they interact with tissue, based upon their wavelength. These differences must be understood by clinicians engaged in laser-based procedures in order to be safe.

The depth of penetration is where 90% of laser energy is deposited and is typically where the surgeon directs their attention. The laser energy is absorbed by tissues which heats and destroys cells. However, not all laser light is absorbed. When laser light interacts with biological tissue, it can also be reflected, transmitted or scattered.[2] Those effects can lead to unintended consequences and complications. Surgeons must be aware of the potential for injury by non absorbed laser energy, not only to tissue, but also to instrumentation, like flexible ureteroscopes and lenses.[3]

Laser energy is released in a pulsed or continuous fashion by a pedal, hand control, or switch.[2,3] Continuous wave lasers have their output expressed in terms of power. Pulsed lasers have their output expressed in terms of energy per pulse. The tissue effect between continuous and pulsed lasers can be significantly different – despite similar chromophores and wavelengths. Pulsed lasers have high peak power bursts leading to high temperatures, with opportunity for cooling in between each pulse (via blood flow, irrigation, etc). These bursts create mechanical effects in addition to thermal (such as the use of holmium for stones and enucleation, each utilizing a different effect). Continuous wave lasers heat tissue to above the ablation threshold and hold it there, without cooling. The overall temperature is less than each peak of a laser pulse, but the constant delivery of energy generates heat above the boiling point and leads to vaporization. Despite these differences, both pulsed and continuous lasers can coagulate and cut/enucleate tissue when applied correctly.[2,4]

Holmium laser enucleation of the prostate (HoLEP)

The first wavelength utilized, and longest running, holmium has proven a safe and reliable energy source for enucleation. Of all the current enucleation techniques, HoLEP has been the most rigorously studied with many randomized trials against TURP and open prostatectomy. Holmium has a 2140 nm wavelength and a high affinity for water. The laser works in a pulsed fashion. The depth of penetration is 0.4 mm.

Multiple approaches are utilized, but all rely upon identification of the surgical capsule and retrograde enucleation along this plane. The original approach utilized incisions at 5 o'clock and 7 o'clock, with enucleation of the middle lobe between the incisions, moving from proximal to the verumontanum to the bladder neck, with release of the lobe off the bladder neck. The lateral lobes are similarly enucleated along the capsule, moving from a clockwise fashion (the right lateral lobe) or counterclockwise (the left lateral lobe). A 12 o'clock incision is often made to separate the right and left lateral lobes. Other surgeons have employed a single bladder neck incision in either the 5 o'clock or 7 o'clock position, with incorporation of the middle lobe with one of the lateral lobes and the other lateral lobe removed after. When no middle lobe is present, a single 6 o'clock incision can be made. And lastly, some surgeons will enucleate a lateral lobe and continue across the anterior connection (12 o'clock) over to the other side, taking the two lateral lobes en bloc.

As regards to laser settings, many different variations can be used. Most use 2.0 J and 50 Hz, but rates as low as 40 HZ and even 30 HZ have been employed. Many surgeons will adjust settings near the verumontanum, many don't. Also, energy is not always used to enucleate and most HoLEP practitioners use a combination of blunt dissection with the beak of the scope, and application of energy.[5-14] Outcomes of selected publications are included in Table 1.

TABLE 1. **HoLEP outcomes – selected publications**

HoLEP Patient n	Follow up	IPSS	Qmax (mL/sec)	PVR (mL)	QoL	Re-op rates	Incontinence	Strictures/ contractures
Ahyai et al[6] 2007 n = 100	3 yr	22.1 ± 3.8 → 2.7 ± 3.2	4.9 ± 3.8 → 29 ± 11	237 ± 163 → 8.4 ± 16	NR	1/100 (1%)	NR	4/100 (4%) 3/100 (3%)
Fayad et al[7] 2011 n = 30	6 mo	22.6 ± 2.5 → 5.5 ± 1.1	7.3 ± 0.9 → 20.8 ± 1.2	NR → 20.3 ± 1.4	NR	NR	NR	NR
Gilling et al[8] 2012 n = 14	7 yr	26.4 ± 6.1 → 8 ± 5.2	8.3 ± 2.2 → 22.1 ± 15.5	116.1 ± 85.1 → NR	4.8 ± 1.1 → 1.5 ± 1.3	NR	NR	NR
Gupta et al[9] 2006 n = 50	1 yr	23.4 ± 4.5 → 5.2 ± 0.2	5.2 ± 4.4 → 25.1 ± 1.1	112 ± 155.9 → < 20	NR	NR	1/50 (2%)	1/50 (2%)
Kuntz et al[10] 2008 n = 42	5 yr	22.1 ± 3.3 → 3 ± 3.2	3.8 ± 3.6 → 24.3 ± 10.1	280 ± 273 → 10.6 ± 24.4	NR	NR	NR	2/60 (3.3%) 1/60 (1.7%)
Montorsi et al[11] 2004 n = 52	12 mo	21.6 ± 6.7 → 4.1 ± 2.3	8.2 ± 3.2 → 25.1 ± 7.2	NR	4.6 ± 1.1 → 1.4 ± 0.9	NR	1/52 (1.7%)	1/52 (1.7%)
Naspro et al[12] 2006 n = 41	2 yr	20.1 ± 5.8 → 7.9 ± 6.2	7.8 ± 3.4 → 19.2 ± 6.3	NR	4.1 ± 0.9 → 1.5 ± 0.9	NR	2/37 (5.4%)	2/37 (5.4%)
Sun et al[13] 2014 n = 82	1 yr	24.4 ± 3.8 → 5.0 ± 2.2	5.3 ±1.9 → 19.8 ± 5.1	115.8 ± 102.6 → 12.7 ± 15.7	4.6 ± 0.7 → 1.6 ± 0.7	NR	NR	3/82 (3.7%)
Wilson et al[14] 2006 n = 30	2 yr	26 ± 1.1 → 6.1 ± 1.0	8.4 ± 0.5 → 21.0 ± 2.0	113.5 ± 15.5 → 33.7 ± 5.5 6 mo follow up	4.8 ± 0.2 → 1.3 ± 0.2	NR	NR	1/30 (3.3%)

HoLEP = holmium laser enucleation of the prostate; IPSS = International Prostate Symptom Score; Qmax = maximal flow rate; PVR = post void residual; QoL = quality of life; Re-op = reoperative rate; NR = not recorded

Thulium laser enucleation of the prostate (ThuLEP)

Thulium is a 2013 nm wavelength continuous laser with shallow penetration of < 0.4 mm. Similar to holmium, thulium is absorbed by water. As thulium is a continuous laser, there is less mechanical effect than with holmium, but higher generation of continuous heat. Given these characteristics, thulium lasers provide excellent hemostasis with minimal mechanical injury to the pericapsular tissue. ThuLEP users describe utilizing a combination of laser energy and blunt dissection to complete an anatomic enucleation along the surgical capsule, similar to the steps described with the original iteration of HoLEP.[15-21] Outcomes of selected publications are included in Table 2.

Greenlight laser enucleation of the prostate (GreenLEP)

One of the newest energies to be utilized for enucleation, KTP has long been used for vaporization and has an extensive following of surgeons. GreenLEP emerged in 2010 and its use has been growing. A combined "vapoenucleation" approach has also been described. KTP is a 532 nm wavelength laser with a high affinity for hemoglobin. KTP has an optical penetration depth of 0.8mm and a coagulation depth of 1 mm-2 mm. KTP operates in a near continuous mode.[1,2]

Multiple units are marketed, including 120 watt and 180 watt systems. Both the 2090 and MoXY side fire fibers have been used for enucleation. The technique is generally to make a "vaporizing

TABLE 2. **ThuLEP outcomes – selected publications**

ThuLEP Patient n	Follow up	IPSS	Qmax (mL/sec)	PVR (mL)	QoL	Re-op rates	Incontinence	Strictures/ contractures
Yang et al[17] 2013 n = 79	1.5 yr	22.7 ± 4.3 → 5.7 ± 2.1	8.7 ± 2.8 → 22.9 ± 12.7	79.5 ± 29.3 → 30.7 ± 15.2	3.9 ± 1.2 → 1.2 ± 1.1	NR	NR	0/79 (0%)
Iacono et al[18] 2012 n = 148	1 yr	21.1 ± 7.1 → 3.9 ± 2.4	8.2 ± 3.7 → 28.7 ± 10.7	146.1 ± 132.3 → 12.9 ± 20.9	4.4 ± 1.3 → 0.9 ± 0.7	NR	NR	2/79 (2.5%)
Zhang et al[19] 2012 n = 71	1.5 yr	24.6 ± 3.2 → 5.2 ± 1.3	6.8 ± 3.9 → 23.4 ± 5.2	64.6 ± 32.5 → 10 ± 1.1	5.6 ± 0.3 → 1.5 ± 0.2	NR	NR	NR
Rausch et al[20] 2015 n = 234	2 yr	18.2 ± 7.4 → 4.5 ± 4.6	10.2 ± 5.2 → 23.5 ± 8.2	131.5 ± 148 → 18.7 ± 40.61	3.9 ± 1.5 → 1.0 ± 0.9	21/23 (9.0%)	8/234 (3.4%)	5/234 (2.1%)
Swiniarski et al[21] 2012 n = 54	3 mo	20.4 ± 2.6 → 6.6 ± 4.5	7.7 ± 3.5 → 23 ± 8.3	166.2 ± 110.5 → 26.5 ± 28.8	4.7 ± 1 → 1.5 ± 1.1	2/54 (3.7%)	1/54 (1.9%)	3/54 (5.6%)

ThuLEP = thulium laser enucleation of the prostate; IPSS = International Prostate Symptom Score; Qmax = maximal flow rate; PVR = post void residual; QoL = quality of life; Re-op = reoperative rate; NR = not recorded

incision" proximal to the verumontanum to identify the surgical capsule. The beak of the scope is then used to mechanically peel the adenoma anteriorly and working clockwise/counterclockwise along the capsule. The laser beam is turned upwards/inwards towards the adenoma, concentrating the energy into the adenoma and away from the capsule. Quick applications of energy can be applied to capsular bleeders.[22-25] Outcomes of selected publications are included in Table 3.

Diode laser enucleation approaches

Two wavelengths of diode lasers have been used to perform laser enucleation – 980 nm and 1318 nm, both of which are continuous wave. Both of these wavelengths have absorption affinities for water and hemoglobin, in essence combining the properties of the laser wavelengths already mentioned. The overall depth of penetration is the highest of the lasers presented in this article at 5.0 mm penetration, making

TABLE 3. **GreenLEP outcomes – selected publications**

GreenLEP/KTP	Follow up	IPSS	Qmax (mL/sec)	PVR (mL)	QoL
Brunken et al[23] 2011 n = 21	6 mo	25.0 ± 6.0 → 5.0 ± 9.0	8.4 ± 2.1 → NR	126.0 ± 80.0 → 11.0 ± 18.0	NR
Elshal et al[24] 2015 n = 53	1 yr	23.0 ± 4.8 → 5.1 ± 4.5	8.0 ± 3.0 → 14.0 ± 7.0	172.0 ± 137.0 → 72.0 ± 89.0	4.0 ± 1.1 → 1.1 ± 1.3
Misrai et al[25] 2015 n = 30	9 mo	15.0 ± 10.0 → 5.0 ± 2.5	6.0 ± 0.5 → 28.0 ± 1.0	100.0 ± 15.75 → 0	4.0 ± 0.25 → 2.0 ± 2.5

GreenLEP = GreenLight laser enucleation of the prostate; IPSS = International Prostate Symptom Score; Qmax = maximal flow rate; PVR = post void residual; QoL = quality of life; NR = not recorded

TABLE 4. **DiLEP outcomes – selected publications**

DiLEP (980 nm)	Follow up	IPSS	Qmax (mL/sec)	PVR (mL)	QoL
Buisan et al[28] 2011 n = 17	3 mo	22.3 ± 4.1 → 7.1 ± 1.1	7.14 ± 2.6 → 21.4 ± 3.6	NR	NR
Yang et al[29] 2013 n = 74	12 mo	12.3 ± 0.6 → 5.0 ± 1.5	6.5 ± 0.4 → 16.0 ± 1.5	103.0 ± 17.0 → 30.0 ± 10.0	NR
Xu et al[30] 2013 n = 40	12 mo	23.5 ± 4.9 → 4.9 ± 1.2	7.9 ± 2.2 → 23.5 ± 3.3	52.6 ± 49.5 → 1.3 ± 3.1	4.4 ± 0.8 → 1.2 ± 0.5
Yang et al[31] 2013 n = 65	7 mo	22.0 ± 2.0 → 7.3 ± 3.1	7.8 ± 0.8 → 17.1 ± 2.4	122.2 ± 57.8 → 22.1 ± 13.9	NR
Yang et al[31] 2013 n = 55	7 mo	23.3 ± 1.7 → 5.5 ± 2.2	7.2 ± 1.1 → 18.6 ± 3.9	117.0 ± 63 → 33.8 ± 16.2	NR

DiLEP = diode laser enucleation of the prostate; IPSS = International Prostate Symptom Score; Qmax = maximal flow rate; PVR = post void residual; QoL = quality of life; NR = not recorded

attention to the technique essential so as to avoid application of energy deeper than the surgical capsule.[3]

Diode laser enucleation of the prostate (DiLEP)

DiLEP utilizes the 980 nm wavelength, pulsed laser. The 4-U incision technique was developed for DiLEP, a modification of the HoLEP approach. The 4-U approach utilizes a series of incisions to enucleate the adenoma from the capsule. The first incisions are at 5 o'clock and 7 o'clock, with a connecting incision between them to remove the median lobe (the first "U"). This is followed by 11 o'clock and 1 o'clock incisions, again connecting them to remove the anterior lobe (the second "U"). Finally, the 7 o'clock and 11 o'clock incisions are connected, and the 1 o'clock and 5 o'clock incisions are connected, to remove the lateral lobes (the third and fourth "U's").[26-31] Outcomes of selected publications are included in Table 4.

TABLE 5. **ELEP outcomes – selected publications**

ELEP (1318 nm)	Follow up	IPSS	Qmax (mL/sec)	PVR (mL)	QoL
Lusuardi et al[32] 2011 n = 30	6 mo	26.9 ± 5.3 → 4.2 ± 1.1	6.8 ± 2.4 → 21.6 ± 1.9	176.5 ± 75.4 → 35.3 ± 8.7	5.1 ± 1.0 → 1.3 ± 0.5
Lusuardi et al[33] 2015 n = 20	6 mo	28.4 ± 5.0 → 4.1 ± 1.2	6.7 ± 2.6 → 21.2 ± 2.2	173.7 ± 82.5 → 33.9 ± 9.3	NR
Hruby et al[34] 2013 n = 43	6 mo	25.9 ± 5.4 → 4.3 ± 1.1	6.9 ± 2.3 → 21.5 ± 1.7	170.5 ± 75.2 → 34.3 ± 8.5	5.2 ± 1.2 → NR

ELEP = eraser laser enucleation of the prostate; IPSS = International Prostate Symptom Score; Qmax = maximal flow rate; PVR = post void residual; QoL = quality of life; NR = not recorded

Eraser laser enucleation of the prostate (ELEP)

The Eraser laser was initially utilized in thoracic surgery for laser lung metastasectomies and only recently has been applied in the field of urology. ELEP employs use of a 1318 nm diode laser. The technique is described as similar to HoLEP, using a 600 micron end fire fiber.[32-34] Outcomes of selected publications are included in Table 5.

Prostate tissue removal

Practitioners have options of several different techniques to remove tissue following prostate enucleation. The conventional method of tissue removal, and most common, is use of a mechanical tissue morcellator. The free floating lobes are engaged within the bladder, which is kept full via one or two inflow lines, and morcellated into small pieces that are suctioned through the handpiece and collected within a sock, or other collection device.[1] Several morcellators are currently marketed. The differences between them are in the mechanism of blade action (reciprocating or rotational blades) and suction characteristics (intermittent or continuous). A mushroom technique has also been described.[15] With this approach the adenoma is enucleated in a retrograde fashion to the level of the bladder neck where, rather than truncating the lobe completely off the bladder neck, the lobes are kept attached to be resected with the use of an electrocautery loop. Leaving the lobes attached is essential as it is necessary for the circuit of monopolar energy, and it keeps the lobe in a more fixed and accessible location. Finally, for larger glands, the lobes can be removed intact via a small cystotomy incision and extraction with ring forceps, as can be done with large bladder stones.

Conclusions

Enucleation techniques are effective treatments for symptomatic BPH. Similar to open prostatectomy, the anatomic principles of endoscopic enucleation make this approach the modern age "surgery of old". As the vast majority of adenoma is removed - if not all, patients should expect minimal regrowth, few complications, and excellent outcomes, as has been shown. Without question, surgeons and industry will continue to strive to find ways and energy sources that improve our ability to treat patients with BPH. What approach and/or energy source is best is still not known. What we do know is that laser energies are here to stay, application of enucleation is growing, and we can likely expect that TURP will continue to be replaced in favor of other approaches. As an example of a LEP procedure the HoLEP is described in detail with a video of the technique available on *The Canadian Journal of Urology* web site (http://www.canjurol.com/how-i-do-it).[35]

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Dr Lori B. Lerner is a consultant and preceptor for Boston Scientific and Lumenis.
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References

1. Tan A, Gilling P. Holmium laser prostatectomy. *BJU Int* 2003;92(6):527-530.
2. Bach T, Muschter R, Sroka R et al. Laser treatment of benign prostatic obstruction: basics and physical differences. *Eur Urol* 2011;61(2):317-325.
3. American Urological Association University. Light amplification by stimulated emission of radiation. Available from URL: https://www.auanet.org/university/core_topic.cfm?coreid=164. Accessed May 2015.
4. Wikipedia. Laser. Available from URL: https://en.wikipedia.org/wiki/Laser. Accessed May 2015.
5. Yin L, Teng J, Huang C, Zhang X, Xu D. 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.
6. Ahyai S, Lehrich K, Kuntz R. Holmium laser enucleation versus transurethral resection of the prostate: 3-year follow-up results of a randomized clinical trial. *Eur Urol* 2007;52(7):1456-1464.
7. Fayad A, Sheikh M, Zakaria T, Elfottoh H, Alsergany R. Holmium laser enucleation versus bipolar resection of the prostate: a prospective randomized study. Which to choose? *J Endourol* 2011;25(8):1347-1352.
8. Gilling P, Wilson L, King C, Westenberg A, Frampton C, Fraundorfer M. Long-term results of a randomized trial comparing holmium laser enucleation of the prostate and transurethral resection of the prostate: Results at 7 years. *BJU Int* 2012;109(3):408-411.
9. Gupta N, Sivaramakrishna, Kumar R, Dogra P, Seth A. Comparison of standard transurethral resection, transurethral vapour resection and holmium laser enucleation of the prostate for managing benign prostatic hyperplasia of 40 g. *BJU Int* 2006;97(1):85-89.
10. Kuntz R, Lehrich K, Ahyai S. Holmium laser enucleation of the prostate versus open prostatectomy for prostates greater than 100 grams: 5-year follow-up results of a randomised clinical trial. *Eur Urol* 2008;53(1):160-166.
11. Montorsi F, Naspro R, Salonia A et al. Holmium laser enucleation versus transurethral resection of the prostate: results from a 2-center, prospective, randomized trial in patients with obstructive benign prostatic hyperplasia. *J Urol* 2004;172(5 Pt 1): 1926-1929.
12. Naspro R, Suardi, N, Salonia A et al. Holmium laser enucleation of the prostate versus open prostatectomy for prostates 70 g: 24-month follow-up. *Eur Urol* 2006;50(3):563-568.

13. 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.
14. Wilson L, Gilling P, Williams A et al. A randomized 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. Zhu Y, Zhuo J, Xu D, Xia S, Herrmann T. Thulium laser versus standard transurethral resection of the prostate for benign prostatic obstruction: A systematic review and meta-analysis. *World J Urol* 2015;509-515.
16. Kyriazis I, Świniarski P, Jutzi S et al. Transurethral anatomical enucleation of the prostate with Tm:YAG support (ThuLEP): Review of the literature on a novel surgical approach in the management of benign prostatic enlargement. *World J Urol* 2015; 33(4):525-530.
17. Yang Z, Wang X, Liu T. Thulium laser enucleation versus plasmakinetic resection of the prostate: a randomized prospective trial with 18-month follow-up. *Urology* 2013;81(2):396-400.
18. Iacono F, Prezioso D, Di Lauro G et al. Efficacy and safety profile of a novel technique. ThuLEP (Thulium laser enucleation of the prostate) for the treatment of benign prostate hypertrophy. Our experience on 148 patients. *BMC Surg* 2012;12(Suppl 1): S21.
19. Zhang F, Shao Q, Herrmann T, Tian Y, Zhang Y. Thulium laser versus holmium laser transurethral enucleation of the prostate: 18-month follow-up data of a single center. *Urology* 2012;79(4):869-874.
20. Rausch S, Heider T, Bedke J et al. Analysis of early morbidity and functional outcome of thulium: yttrium-aluminum-garnet laser enucleation for benign prostate enlargement: patient age and prostate size determine adverse surgical outcome. *Urology* 2015;85(1):182-188.
21. Swiniarski P, Stepien S, Dudzic W et al. Thulium laser enucleation of the prostate (TmLEP) vs. transurethral resection of the prostate (TURP): evaluation of early results. *Cent European J Urol* 2012;65(3):130-134.
22. Sancha F, Rivera V, Georgiev G, Botsevski A, Kotsev J, Herrmann T. Common trend: move to enucleation—is there a case for GreenLight enucleation? Development and description of the technique. *World J Urol* 2015;33(4):539-547.
23. Brunken C, Seitz C, Tauber S, Schmidt R. Transurethral GreenLight laser enucleation of the prostate—a feasibility study. *J Endourol* 2011;25(7):1199-1201.
24. Elshal A, Elkoushy M, El-Nahas A et al. GreenLight™ Laser (XPS) photoselective vapo-enucleation versus holmium laser enucleation of the prostate for the treatment of symptomatic benign prostatic hyperplasia: a randomized controlled study. *J Urol* 2015;193(3):927-934.
25. Misrai V, Guillotreau J, Bordier B, Woo H, Gomez-Sancha F. En bloc enucleation of the prostate using a surgical 532-nm laser (GreenLEP) technique: initial results. Abstract MP13-17 American Urological Association Annual Meeting 2015.
26. Lusuardi L, Mitterberger M, Hruby S et al. Update on the use of diode laser in the management of benign prostate obstruction in 2014. *World J Urol* 2015;33(4):555-562.
27. Seitz M, Sroka R, Gratzke C et al. The diode laser: a novel side-firing approach for laser vaporisation of the human prostate—immediate efficacy and 1-year follow-up. *Eur Urol* 2007;52(6); 1717-1722.
28. Buisan O, Saladie J, Ruiz J et al. Enucleacion prostatica con laser de diodo (DiLEP): tecnica y resultados iniciales. *Actas Urol Esp* 2011;35(1):37-41.
29. Yang S, Hsieh C, Lee Y, Chang S. Diode laser (980 nm) enucleation of the prostate: A promising alternative to transurethral resection of the prostate. *Lasers Med Sci Lasers in Medical Science* 2013;28(2): 353-360.
30. 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.
31. Yang S, Hsieh C, Chiang I, Lin C, Chang S. Prostate volume did not affect voiding function improvements in diode laser enucleation of the prostate. *J Urol* 2013;189(3):993-998.
32. Lusuardi L, Myatt A, Sieberer M, Jeschke S, Zimmermann R, Janetschek G. Safety and efficacy of eraser laser enucleation of the prostate: preliminary report. *J Urol* 2011;186(5):1967-1971.
33. Lusuardi L, Hruby S, Janetschek G et al. Laparoscopic adenomectomy versus Eraser laser enucleation of the prostate. *World J Urol* 2015;33(5):691-696.
34. Hruby S, Sieberer, M, Schätz T. Eraser laser enucleation of the prostate: technique and results. *Eur Urol* 2013;63(2):341-346.
35. Kelly DC, Das A. Holmium laser enucleation of the prostate technique for benign prostatic hyperplasia. *Can J Urol* 2012; 19(1):6131-6134.