Development of Medical Lasers for Treatment on Benign Prostatic Hyperplasia

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Benign prostatic hyperplasia (BPH) is one of the most common causes of lower urinary tract symptoms in aged males. Many patients with BPH may go on to require surgical intervention. At present, transurethral resection of the prostate (TURP) is the gold standard for BPH treatment owing to its minimal damage, low cost, and long-term efficacy. However, many complications associated with TURP represent major drawbacks of this procedure. These complications include hemorrhage, perforation of the prostatic capsule, urinary incontinence, retrograde ejaculation, urethral stricture, bladder neck spasm, transurethral resection syndrome (TURS), and more. The incidence of long-term complications is 32.14%.[1] TURS is one of the most serious complications with an incidence of 2%.[2] TURS can lead to death if not treated promptly. Due to the high incidence of complications, surgical treatment with TURP has been limited.

With the development of the medical techniques, medical lasers are emerging as new treatments for BPH. Medical lasers include holmium laser, green laser, 1470 nm diode laser, 980 nm diode laser, 2 μm continuous wave (CW) laser, and others. One advantage of medical lasers for BPH treatment is no existence of TURS. In addition, it is a convenient operation, with minimal bleeding and a short hospital stay. The surgical treatment of laser vaporesection for BPH treatment is gradually accepted by clinicians due to its apparent advantages.[3] This study is aimed to introduce the development of medical lasers used to treat BPH.

Medical Lasers

Holmium:YAG laser

The wavelength of holmium:YAG laser is 2140 nm and its penetration depth in tissue is only 0.4 mm. The area of heat damage ranges from 0.5 to 1.0 cm when the holmium:YAG laser works. The holmium:YAG laser is an ideal tool for cutting tissue due to the characteristics listed above.[4]

Holmium laser enucleation of the prostate (HoLEP) is the classic clinical surgical treatment for BPH by using holmium:YAG laser. It was first reported in 1998.[5] During the operation of HoLEP, the prostate is removed completely and pushed into the bladder. The prostate tissue is removed from the bladder using a prostatic tissue morcellator. HoLEP has such advantages as quick recovery, little bleeding, short hospital stay, and more. TURS does not occur because the irrigating fluid is normal saline during the operation. Regarding the treatment of prostates greater than 100 grams, a randomized controlled trial comparing HoLEP to open prostatectomy (OP) showed a shorter time in hospital stay after HoLEP (70 vs. 250 h, $P < 0.01$) and a lower rate of blood transfusion (0% vs. 13.3%, $P < 0.01$).[6] When the prostate over 60 grams was treated, a randomized controlled trial showed less blood loss during HoLEP than that during TURP (0.47 ± 0.46 vs. 0.63 ± 0.6 g/dl, $P < 0.05$).[7] A study analyzed the 12-month outcome of low-powered HoLEP (LP-HoLEP) for patients with symptomatic benign prostatic obstruction (BPO) showed that maximum flow rate (Qmax) (12 vs. 29.3 ml/s), postvoid residual (PVR) urine volume (155.00 vs. 11.15 ml), International Prostate Symptom Score (IPSS) (22 vs. 6), and quality of life (QoL) score (5 vs. 1) had improved significantly (all $P < 0.001$) at the 12-month follow-up period.[8] The operation of HoLEP showed excellent results for BPH patients with anticoagulant therapy or with bleeding disorders.[9] Some scholars reported that HoLEP had such several shortcomings as longer learning curve and a longer operation time.[10] However, this technology has been improved, and the time of the learning curve has been reduced.[11]

Thulium vapoenucleation of the prostate (ThuVEP) is another method for BPH treatment using the holmium:YAG

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laser. A study retrospectively assessed the 5-year outcomes of ThuVEP in patients with BPO. The result proved that ThuVEP was a durable procedure with regard to improvement on micturition and reducing of PSA, as well as the reintervention improvement on rate after ThuVEP during long-term follow-up.[12] ThuVEP is a safe and effective procedure for the treatment of symptomatic BPO as HoLEP. Both procedures produce equivalent and satisfactory immediate micturition improvement with low perioperative morbidity.[13,14]

Green laser

The wavelength of green laser is 532 nm, which has a tissue penetration depth of 0.8 mm. One of the advantages of green laser is its effective result in controlling bleeding. The maximum power of the green laser is 180 W, which was first introduced in 2011.[15,16]

The green laser for BPH treatment is named photoselective green laser vaporization of the prostate (PVP). The operation of PVP has advantages of little bleeding, quick recovery, short hospital stay, no TURS, and a short learning curve time.[17] The hemostasis of green lasers is excellent, which allows PVP appling to patients of BPH with anticoagulant therapy.[18] PVP also applies to large-volume prostate patients. A study was performed to evaluate the results of GreenLight XPS photovaporization (PVP/XPS) with intraoperative transrectal ultrasonographic monitoring for the treatment of large BPH, with volume >80 ml. The results showed that there was a significant improvement in IPSS (4.0 vs. 19.5), QoL score (1 vs. 5), Qmax (19.1 vs. 8.2 ml/s), and PVR (26 vs. 100 ml) (all $P < 0.001$). Furthermore, the treatment of large BPH with PVP/XPS is safe and effective.[19] A study comparing PVP to OP on large volume prostate (>80 ml) showed a shorter hospital stays after PVP than after OP (48.00 vs. 0.44 h, $P < 0.05$) and a lower rate of blood transfusion (0 vs. 13%, $P < 0.05$).[20] Another study comparing PVP to TURP showed a shorter catheterization time (1.25 vs. 4.67 d, $P < 0.01$) while PVP showed a higher rate of symptomatic relief after 1 year of follow-up (45.6% vs.18.2%, $P < 0.01$).[21] The study of calves model had established the long-term durability of PVP for the treatment of BPH. The rate of reoperation was 4.8% in a follow-up of 57 months.[22] Another study showed PVP to be an effective, safe, and durable treatment for men in acute urinary retention (AUR) with a catheter-free rate of 96%. The improvement of symptoms was similar to those who did not present in AUR.[23]

Two μm continuous wave laser

Two μm CW laser is also known as thulium laser, which has a wavelength of 2013 nm and a penetration depth in tissue of 0.3 mm. Two μm CW laser has an excellent cutting capacity similar to holmium:YAG laser and also has better hemostasis similar to the green laser. Operations using 2 μm CW laser has such advantages as minimal bleeding, short operation time, quick recovery, short hospital stay, few complications, and more.[24]

The method of using 2 μm CW laser for treating BPH includes 2 μm (thulium) laser resection of the prostate-tangerine technique (TmLRP-TT), and 2 μm (thulium) laser enucleation of the prostate (ThuLEP).[25,26] A prospective analysis of 51 patients with previously negative transrectal prostate biopsies, who underwent surgical treatment using TmLRP-TT showed that the mean IPSS, QoL score, Qmax, and PVR, changed notably in a 6-month follow-up period (22.5 ± 6.9 vs. 6.1 ± 3.2, 4.8 ± 1.3 vs. 1.1 ± 0.9, 7.3 ± 4.5 vs. 18.9 ± 7.1 ml/s, and 148.7 ± 168.7 vs. 28.4 ± 17.9 ml; all $P < 0.001$).[27] ThuLEP offers complete removal of the transition zone regardless of the size of the prostate and produces good clinical results when comparing ThuLEP with OP or TURP.[28]

A new method for BPH treatment, named the "five-part method" of 2 μm CW laser vaporesection, was reported.[29] This method is named "five-part method" because the entire prostate is separated into five parts. During the operation, the urethral sphincter is easily distinguishable, which results in a reduced rate of incontinence. The method is easy to master for beginners with advantages of safety, simplicity, short operation time, short hospital stay, and little bleeding. "Five-landmark grooves" of 2 μm CW laser vaporesection was reported in 2014.[30] This method separated the prostate into three parts using five-landmark grooves and achieved good results.

Diode laser

Diode laser has an excellent cutting capacity and produces good hemostasis similar to the 2 μm CW laser, which has been used for BPH treatment in recent years. The wavelength of commonly used diode lasers are 980 and 1470 nm. The operation used diode laser has such advantages as little bleeding, quick recovery, short hospital stay, few complications, and more.[31,32] The straight light and lateral light of the 1470 nm diode laser make the operation process more easier compared with those of Holmium:YAG laser and 2 μm CW laser.

The method of using a diode laser for treating BPH includes diode laser enucleation of the prostate (DiLEP) and diode laser vaporization of the prostate. A report showed all the 17 patients who underwent the operation using DiLEP were discharged from the hospital 24 h after the operation. The improvement in the IPSS (22.3 ± 4.1 vs. 7.1 ± 1.06, $P < 0.05$) and in the Qmax (7.14 ± 2.6 vs. 21.4 ± 3.6 ml/s, $P < 0.05$) was sustainable after three months of follow-up.[33] Another study compared the outcomes of diode laser vaporization of the prostate to that of TURP showed diode laser vaporization offered a safer and more feasible option in the management of patients with symptomatic BPH.[34]

A new method for BPH treatment, called the "honeycomb" evaporation technique uses a straight light beam (a 1470 nm laser), was reported in 2015. The report showed that the mean IPSS, QoL score, Qmax, and PVR, changed notably in a 3-month followup period (26.0 ± 1.9 vs. 9.6 ± 1.6, 6.0 ± 0.6 vs. 2.7 ± 0.5, 6.9 ± 1.7 vs. 16.8 ± 4.4 ml/s, 163.7 ± 19.9 vs. 20.1 ± 9.6 ml; all $P < 0.05$).[35]

Summary of Medical Lasers

Medical lasers have the advantages of little injury, strong hemostatic effect, quick cutting speed, and ease of use. Operations that use medical lasers have the advantages of producing little bleeding, quick recovery, short hospital stay, no TURS, and fewer complications. Complications of medical lasers include secondary hemorrhage, urethral stricture, urinary incontinence, and decrease of sexual function. Kim *et al*.[36] reported that HoLEP did not influence overall sexual function including erectile function.

During operations on BPH, different kinds of medical lasers have their own disadvantages. The holmium:YAG laser has a perfect cutting effect; however, its hemostatic effect is poor. The green laser has perfect hemostatic effect; however, the speed of vaporization is slow, and pathological specimen cannot be obtained during the operation. The 2 μm CW laser and diode laser both have perfect cutting effect and hemostatic effect; however, it is difficult for the two kinds of lasers to cut the large middle lobe of the prostate protruding into the bladder. The other disadvantage of medical lasers is that the equipment is expensive, meaning that fewer hospitals can afford them.

Which is the best medical laser? The Holmium:YAG laser has the best cutting capacity and the green laser has the best vaporized hemostatic function. The 2 μm CW laser and diode laser have both functions, but the 1470 nm diode laser is better than the 2 μm CW laser. The methods of using medical lasers for the treatment of BPH include HoLEP, PVP, TmLRP-TT, DiLEP, and more. Which is the best method? A clinical research addressing this issue showed that every method has its own advantages.[37] Doctors should choose the most appropriate method that they can do their best.

Conclusion

Medical lasers have not been used widely due to their high price and because TURP is still considered the standard of BPH treatment. With the increasing health expenditure, medical lasers will be increasingly used in the clinic because of their advantages. In the future, operations using medical lasers for BPH treatment may replace TURP and become the new gold standard.

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Conflicts of interest

There are no conflicts of interest.

References

1. Meng YL, Sun GX, Wang W, Xu H, Yang H, Chen KQ. Holmium laser enucleation of the prostate versus transurethral resection of the prostate: A comparison of clinical complication. J Clin Urol 2014;29:1101-3. doi: 10.13201/j.issn.1001-1420.2014.12.019.
2. Kelly DC, Das A. Holmium laser enucleation of the prostate technique for benign prostatic hyperplasia. Can J Urol 2012;19:6131-4.
3. Maheshwari PN, Joshi N, Maheshwari RP. Best laser for prostatectomy in the year 2013. Indian J Urol 2013;29:236-43. doi: 10.4103/0970-1591.117286.
4. Grande M, Facchini F, Moretti M, Larosa M, Leone M, Ziglioli F, *et al.* History of laser in BPH therapy. Urologia 2014;81 Suppl 23:S38-42. doi: 10.5301/RU.2014.11985.
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;12:457-9. doi: 10.1089/end.1998.12.457.
6. Kuntz RM, Lehrich K, Ahyai SA. 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;53:160-6. doi: 10.1016/j.eururo.2007.08.036.
7. Jhanwar A, Sinha RJ, Bansal A, Prakash G, Singh K, Singh V, *et al.* Outcomes of transurethral resection and holmium laser enucleation in more than 60 g of prostate: A prospective randomized study. Urol Ann 2017;9:45-50. doi: 10.4103/0974-7796.198904.
8. Becker B, Gross AJ, Netsch C. Safety and efficacy using a low-powered holmium laser for enucleation of the prostate (HoLEP): 12-month results from a prospective low-power hoLEP series. World J Urol 2018;36:441-7. doi: 10.1007/s00345-017-2159-5.
9. El Tayeb MM, Jacob JM, Bhojani N, Bammerlin E, Lingeman JE. Holmium laser enucleation of the prostate in patients requiring anticoagulation. J Endourol 2016;30:805-9. doi: 10.1089/end.2016.0070.
10. Fayad AS, Sheikh MG, Zakaria T, Elfottoh HA, Alsergany R. Holmium laser enucleation versus bipolar resection of the prostate: A prospective randomized study. Which to choose? J Endourol 2011;25:1347-52. doi: 10.1089/end.2011.0059.
11. Lee SH, Choi JI, Moon KY, Na W, Lee JB. Holmium laser enucleation of the prostate: A modified enucleation technique and initial results. J Urol 2012;187:1336-40. doi: 10.4111/kju.2012.53.11.779.
12. Gross AJ, Orywal AK, Becker B, Netsch C. Five-year outcomes of thulium vapoenucleation of the prostate for symptomatic benign prostatic obstruction. World J Urol 2017;35:1585-93. doi: 10.1007/s00345-017-2034-4.
13. Mulawkar P. Re: A prospective, randomized trial comparing thulium vapoenucleation with holmium laser enucleation of the prostate for the treatment of symptomatic benign prostatic obstruction: Perioperative safety and efficacy. World J Urol 2018;36:499. doi: 10.1007/s00345-017-2142-1.
14. Hong K, Liu YQ, Lu J, Xiao CL, Huang Y, Ma LL. Efficacy and safety of 120-W Thulium: Yttrium-Aluminum-Garnet vapoenucleation of prostates compared with holmium laser enucleation of prostates for benign prostatic hyperplasia. Chin Med J 2015;128:884-9. doi: 10.4103/0366-6999.154282.
15. Chughtai B, Te A. Photoselective vaporization of the prostate for treating benign prostatic hyperplasia. Expert Rev Med Devices 2011;8:591-5. doi: 10.1586/erd.11.25.
16. Zorn KC, Liberman D. GreenLight 180W XPS photovaporization of the prostate: How I do it. Can J Urol 2011;18:5918-26.
17. Wang X, Liu M, Zhang YG, Zhu SC, Wan B, Wang JY. Photoselective vaporesection of the prostate with an end-firing lithium triborate crystal laser. Chin Med J 2017;130:636-41. doi: 10.4103/0366-6999.201593.
18. Piotrowicz G, Syryło T, Jedynak R, Zieliński H. Efficacy and safety of photoselective vaporization of the prostate with 120 W 532 nm laser in patients with benign prostatic hyperplasia on anticoagulation or antiplatelet therapy: Observations on long-term outcomes. Photomed Laser Surg 2018;36:273-83. doi: 10.1089/pho.2017.4367.
19. Thoulouzan M, Perrouin-Verbe MA, Calves J, Deruelle C, Joulin V, Valeri A, *et al.* Outcomes of GreenLight XPS-180W laser photovaporization for BPH larger than 80 mL. Prog Urol 2017;27:489-96. doi: 10.1016/j.purol.2017.04.001.
20. Skolarikos A, Papachristou C, Athanasiadis G, Chalikopoulos D, Deliveliotis C, Alivizatos G. Eighteen-month results of a randomized prospective study comparing transurethral photoselective vaporization with transvesical open enucleation for prostatic adenomas greater than 80 cc. J Endourol 2008;22:2333-40. doi: 10.1089/end.2008.9709.
21. Cimino S, Voce S, Palmieri F, Favilla V, Castelli T, Privitera S, *et al.* Transurethral resection of the prostate (TURP) vs. GreenLight photoselective vaporization of benign prostatic hyperplasia: Analysis

of BPH 6 outcomes after 1 year of follow-up. Int J Impot Res 2017;29:240-3. doi: 10.1038/ijir.2017.30.
22. Calves J, Thoulouzan M, Perrouin-Verbe MA, Joulin V, Valeri A, Fournier G. Long-term patient-reported clinical outcomes and reoperation rate after photovaporization with the XPS-180W GreenLight laser. Eur Urol Focus 2017. pii: S2405-4569(17)30243-2. doi: 10.1016/j.euf.2017.10.006.
23. Goueli R, Meskawi M, Thomas D, Hueber PA, Tholomier C, Valdivieso R, *et al.* Efficacy, safety, and durability of 532 nm laser photovaporization of the prostate with GreenLight 180 W XPS in men with acute urinary retention. J Endourol 2017;31:1189-94. doi: 10.1089/end.2017.0488.
24. Cao Y, Luo GH, Luo L, Yang XS, Hu JX, Shi H, *et al.* Re-epithelialization resulted from prostate basal cells in canine prostatic urethra may represent the ideal healing method after two-micron laser resection of the prostate. Asian J Androl 2015;17:831-8. doi: 10.4103/1008-682X.146972.
25. Liu X, Wang Y, Gao J, Shan Y. Comparison of 120 W 2-μm laser resection of the prostate outcomes in patients with or without preoperative urinary retention. Wideochir Inne Tech Maloinwazyjne 2016;11:223-8. doi: 10.5114/wiitm.2016.63352.
26. Kyriazis I, Świniarski PP, Jutzi S, Wolters M, Netsch C, Burchardt M, *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;33:525-30. doi: 10.1007/s00345-015-1529-0.
27. Zhuo J, Wei HB, Zhang F, Liu HT, Zhao FJ, Han BM, *et al.* Two-micrometer thulium laser resection of the prostate-tangerine technique in benign prostatic hyperplasia patients with previously negative transrectal prostate biopsy. Asian J Androl 2017;19:244-7. doi: 10.4103/1008-682X.168790.
28. Herrmann TR, Bach T, Imkamp F, Georgiou A, Burchardt M, Oelke M, *et al.* Thulium laser enucleation of the prostate (ThuLEP): Transurethral anatomical prostatectomy with laser support. Introduction of a novel technique for the treatment of benign prostatic obstruction. World J Urol 2010;28:45-51. doi: 10.1007/s00345-009-0503-0.
29. Ren XL, Bao GC, Xia HB, Gao ZM, Pang ZL, Lan DY, *et al*. "Five-part method" of two-micron continuous-wave laser vaporesection in treating benign prostatic hyperplasia. J Clin Urol 2016;31:250-2. doi: 10.13201/j.issn.1001-1420.2016.03.015.
30. Wang YZ, Wang LL, Liu RX, Jiang LM. Effectiveness analysis of 2 micron laser vaporesection of prostate by five-landmark grooves in patients with benign prostatic hyperplasia. China Med 2014;9:93-6. doi: 10.3760/cma.issn.1673-4777.2014.01.027.
31. Cetinkaya M, Onem K, Rifaioglu MM, Yalcin V. 980-nm diode laser vaporization versus transurethral resection of the prostate for benign prostatic hyperplasia: Randomized controlled study. Urol J 2015;12:2355-61. doi: 10.22037/uj.v12i5.2839.
32. Zhao Y, Liu C, Zhou G, Yu C, Zhang Y, Ouyang Y. A retrospective evaluation of benign prostatic hyperplasia treatment by transurethral vaporization using a 1470 nm laser. Photomed Laser Surg 2013;31:626-9. doi: 10.1089/pho.2013.3504.
33. 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;35:37-41. doi: 10.1016/j.acuro.2010.08.003.
34. 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;84:526-32. doi: 10.1016/j.urology.2014.05.027.
35. Zhao YW, Hao XH. Study of " honeycomb" evaporation technique with straight light beam of 1470nm laser in treating benign prostatic hyperplasia. J Contemp Urol Reprod Oncol 2015;7:219-22. doi: 10.387/j.jssn.1674-4624.2015.04.008.
36. Kim SH, Yang HK, Lee HE, Paick JS, Oh SJ. HoLEP does not affect the overall sexual function of BPH patients: A prospective study. Asian J Androl 2014;16:873-7. doi: 10.4103/1008-682X.132469.
37. Cho MC, Park J, Kim JK, Cho SY, Jeong H, Oh SJ. Can preoperative detrusor underactivity influence surgical outcomes of 120 W HPS vaporization of the prostate (PVP) or holmium laser enucleation of the prostate (HoLEP)? A serial 3-year follow-up study. Neurourol Urodyn 2018;37:407-16. doi: 10.1002/nau.23317.