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RESEARCH

A comparative study of transurethral 450 nm DiLVP and 1470 nm DiLEP in the treatment of benign prostatic hyperplasia

Zhichao Wang[1,2] · Qingfei Xing[3] · Xinghua Gao[3] · Mengzhen Qiu[3] · Longyang Zhang[2]

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Abstract

To compare the clinical effects of 450 nm diode laser vaporisation of the prostate (450 nm DiLVP) and 1470 nm diode laser enucleation of the prostate (1470 nm DiLEP) in the surgical treatment of benign prostate hyperplasia (BPH). BPH patients who were treated with 450 nm DiLVP or 1470 nm DiLEP in the Department of Urology of Jinan Central Hospital from November in 2021 to November in 2023 were selected for retrospective analysis. The assessment indexes included: (1) Preoperative general information; (2) Perioperative indicators; (3) Postoperative follow-up indicators(followed up at 1 and 3 months after surgery). A total of 128 BPH patients were included in the study, 63 in the experimental group with 450 nm DiLVP and 65 in the control group with 1470 nm DiLEP. There was no significant difference in the baseline information between the two groups ($P>0.05$). Compared with the 1470 nm DiLEP group, the operation time, the laser energy consumption and bladder irrigation time were significantly reduced in the 450 nm DiLVP group ($P<0.001$). At 3 months postoperatively, Qmax relief was significant in the 1470 nm DiLEP group ($P=0.023$). (1) Perioperatively, compared with the 1470 nm DiLEP, 450 nm DiLVP has shorter operation time, irrigation time, and laser energy consumption; (2)Postoperative follow-up: 450 nm DiLVP and 1470 nm DiLEP have similar efficacy in improving BPH symptoms; 1470 nm DiLEP may have greater impact on max urinary flow rate in long-tem follow-up, which needs further verification.

Keywords Benign prostatic hyperplasia · 450 nm diode laser · 1470 nm diode laser · Sexual function · Complications

Introduction

Benign prostatic hyperplasia (BPH) is one of the most common conditions causing lower urinary tract symptoms (LUTS) in middle-aged and older men. Lower urinary tract symptoms secondary to BPH are positively correlated with age, affecting more than one-third of older men worldwide [1, 2] and negatively affecting patients' quality of life (QoL) [3]. Whereas the exact etiology of prostate enlargement is not fully understood, aging is necessary factor for the development of BPH [4]. Histologically the prevalence of BPH increases with age and generally occurs after the age of 40 years, with a prevalence of BPH of > 50% in the male population at the age of 60 years and up to 83% at the age of 80 years [5].

However, the treatment of BPH still faces some problems and challenges. For surgical treatment, transurethral resection of the prostate (TURP) has been the gold standard for surgical treatment of BPH when the prostate volume is between 30 and 80 ml [6]. Nevertheless, it is true that

✉ Zhichao Wang
wzc988110@163.com

✉ Longyang Zhang
zly250013@163.com

Qingfei Xing
xingqingfei@126.com

Xinghua Gao
Gaoxing2000@163.com

Mengzhen Qiu
qiumengzhen1994@126.com

[1] The Fourth Affiliated Hospital of Soochow University, Medical Center of Soochow University, Suzhou Dushu Lake Hospital, Suzhou, China

[2] Jinan Central Hospital, Shandong University, Jinan, China

[3] Central Hospital Affiliated to Shandong First Medical University, Jinan, China

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postoperative bleeding, transurethral resection syndrome (TURS) and mortality have been concerns [7–9].

According to recent literature, diode lasers are capable of achieving the goal of precise resection of prostate tissue with minimal bleeding through excimer cutting, vaporisation and coagulation [10, 11]. 450 nm and 1470 nm are two commonly used wavelengths of diode lasers, which have different characteristics and clinical applications.

As a shorter wavelength laser, the 450 nm diode laser has a strong tissue absorption and vascular occlusion effect. It can quickly and effectively cut and vaporise prostate tissue with less risk of bleeding [12]. However, the shorter wavelength and deeper penetration depth of the 450 nm diode laser may limit its application to large prostate volumes. The 1470 nm diode laser has strong penetration and tissue coagulation effects. It can effectively enucleate prostate tissue with less risk of thermal damage and postoperative complications [13, 14]. Due to its longer wavelength and higher laser heating capacity, the 1470 nm diode laser has advantages in the application of large prostate volumes [15].

However, despite the advantages of 450 nm and 1470 nm diode lasers in prostate laser surgery, comparative studies on the clinical applications of the two lasers are still limited. Further exploration of their differences and merits in terms of surgical outcomes, postoperative recovery and patient satisfaction is needed.

Therefore, in this study, for the first time, we compared 450 nm diode laser vaporisation of the prostate (450 nm DiLVP) with 1470 nm diode laser enucleation of the prostate (1470 nm DiLEP) in the surgical treatment of BPH.

Methods

Research object

Patients who underwent transurethral 450 nm DiLVP or 1470 nm DiLEP in the Department of Urology of Jinan Central Hospital for BPH from November in 2021 to November in 2023 were selected for this study, and patient data were collected for retrospective analysis and comparison. The study was approved by the Ethics Committee of Jinan Central Hospital, and informed consent was obtained from all participants. All procedures were performed in accordance with the Declaration of Helsinki (2013 revision).

Inclusion criteria: (1) Clinical manifestations, imaging examinations, and postoperative pathology met the diagnostic criteria of BPH; (2) Comply with the indications for surgical treatment of BPH according to urology guidelines, including having moderate to severe LUTS and has significantly affected the quality of life, poor results of drug treatment or refusal of drug treatment, combination of recurrent urinary retention or urinary tract infections or hematuria; (3) Have received 450 nm DiLVP or 1470 nm DiLEP surgical treatment; (4) Patients with informed consent and good compliance.

Exclusion criteria: (1) Combined bladder cancer, prostate cancer and history of prostate or urethra surgery; (2) Combined neurogenic bladder; (3) Severe urinary tract infections; (4) Serious coagulation disorders; (5) Combination of severe cardiovascular and cerebrovascular diseases.

Preoperative Preparation

A comprehensive medical history was taken by the patient's supervising physician for both groups, which consisted of: (1) Present medical history; (2) Past medical history; (3) Personal history and Information; (4) International prostate symptom score(IPSS); (5) Quality of life(QoL); (6) International index of erectile function(IIEF-5); (7) Indicators of sexual dysfunction(including the incidence of retrograde ejaculation and haematogenous sperm).

Both groups of patients were detailed and complete physical examination and urology specialisation examination, and the diagnosis was further clarified by urological ultrasound, abdominal urography, computed tomography(CT) and other imaging examinations. In case of conflicting diagnostic imaging findings, CT findings used as the final diagnostic criterion, while malignancy cannot be excluded, the rectal prostate biopsy is performed to further clarify the diagnosis. Postvoiding residual urine volume(PVR) and maximal urinary flow rate(Qmax) examination were used to determine the degree of bladder outlet obstruction(BOO).

Preoperative assessment of surgical risk was performed in accordance with the American Society of Anesthesiologists(ASA) grading, surgical risks and surgical precautions were fully explained to the patients and their families, and informed consent for surgery was signed.

Surgical methods

Both groups of patients were operated in the lithotomy position, and the anaesthesia mode was epidural anaesthesia or general anaesthesia by tracheal intubation. Both surgeries were performed by the same chief urologist with extensive surgical experience. Images of the 450 nm DiLVP procedure can be found in the Fig. 1.

(1) 450 nm DiLVP group:

a. Surgical instruments were selected as 450 nm laser diode treatment machine, straight optical fibre and prostate resectoscope. Auxiliary Surgical Instruments had been well prepared.

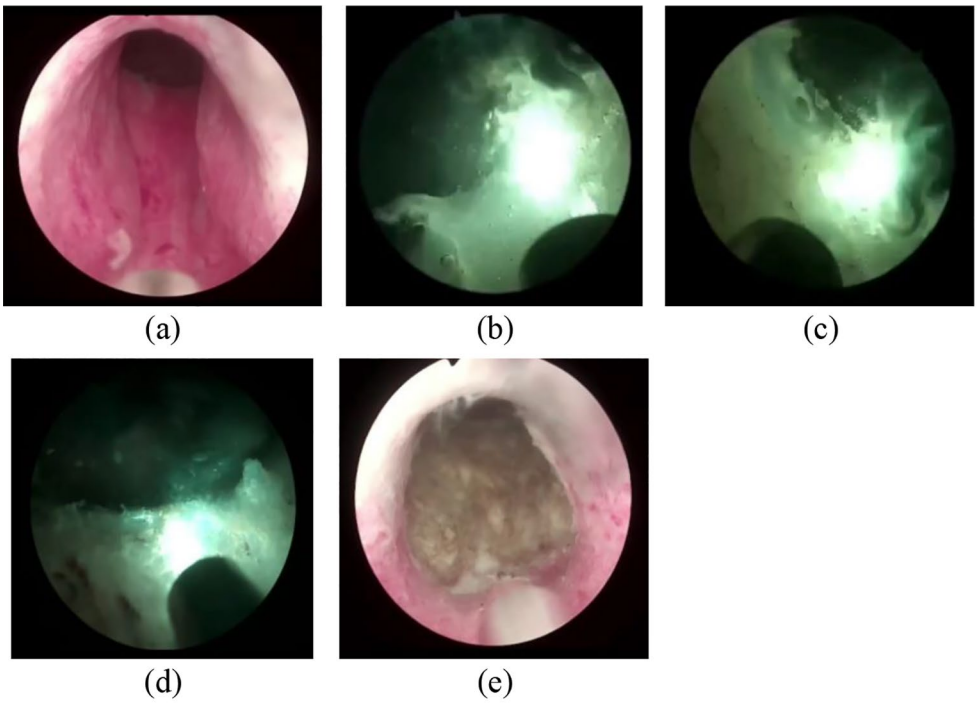

Fig. 1 Pictures of 450 nm DiLVP surgical operation procedure. (**a**) observation of anatomical structures; (**b**) vaporisation of the left lobe; (**c**) vaporisation of the right lobe; (**d**) vaporisation of the middle lobe; (**e**) postoperative visualisation of the prostate region

b. Firstly, continuous bladder irrigation was performed using 0.9% saline maintaining a perfusion pressure of 60 cm H_2O.
c. Subsequently, prostate resectoscope was passed through the urethra and placed into the urethro-prostatic section to observe and locate the important anatomical structures, including the bilateral opening position of the ureter, the urethral sphincter, and the seminal colliculus, and to establish the internal water circulation of the fibre through the irrigation solution.
d. After that, straight optical laser fibre was inserted with the 450 nm diode laser vaporisation power set at 150 W. Prostatic hyperplasia was vaporised and removed from the right lobe and the left lobe of the prostate close to the bladder neck in a sequential manner at 5 and 7 o'clock location, respectively. For the middle lobe of the prostate, anterior and posterior sweeping vaporisation was used to make the urogenital tract smooth and stable, and to keep the surgical level and the plane of the triangle flat. The bladder was kept moderately full during the operation, and care was taken to avoid damage to the bladder, external urethral sphincter and other important surrounding tissues.
e. Finally, haemostasis was given to the postoperative partial bleeding leisions using 980 nm laser power set at 50 W. The procedure was completed after stopping the water circulation and emptying the bladder, which showed a well-conditioned sphincter in the urethra prostatic area and patent urethral flow tract. After removing the endoscope, passive urination test was performed. And after satisfactory urination, indwell F18 three-lumen balloon catheter, inject 20 ml normal saline into the balloon, and continuously flush the bladder with sterile normal saline after operation.

(2) 1470 nm DiLEP group:

a. Surgical instruments were selected as 1470 nm diode laser treatment machine, 600 μm diode laser fibre, prostate resectoscope and tissue morcellator. Auxiliary Surgical Instruments had been well prepared.
b. Firstly, prostate resectoscope passed through the urethra and positioned in the plane of the surgical capsula of the prostate above the seminal colliculus, and internal water circulation is established.
c. Subsequently, 1470 nm diode laser was used to locate the 5 and 7 o'clock positions in the field of view of the bladder neck, and prostate tissue was incised longitudinally up to the surgical capsula of the prostate, and laser vapour dissection was performed on the proximal part of the seminal colliculus transversely connecting the 5 and 7 o'clock positions, enucleating the tissue of the middle lobe and pushing it into the bladder.
d. After that, the left and right lobes of the prostate were cut along the capsula by laser enucleation respectively, and the enucleated tissues were pushed into the bladder at 12 o'clock position of the bladder neck, and care was taken to protect the bladder, the external urethral sphincter, and other important peripheral tissues during the operation.

e. Finally, the enucleated prostate tissue is observed in the bladder cavity, and the tissue morcellator is used for thorough crushing and suctioning out residual tissue, and the operation is completed with examination of bleeding and repair of the prostate surgical wound. After removing the endoscope, passive urination test was performed. And after satisfactory urination, indwell F18 three-lumen balloon catheter, inject 20 ml normal saline into the balloon, and continuously flush the bladder with sterile normal saline after operation.

Postoperative management

After surgery, the patient was placed in a decubitus position, and was given routine cardiac, blood pressure, blood oxygen monitoring, timely review of blood routine, urine routine, blood ion and other laboratory tests, and the patient's vital signs were closely observed. The patients were instructed to move both lower limbs or pneumatic compression therapy appropriately to avoid deep vein thrombosis. Postoperatively, the patient was given saline continuous bladder irrigation, and the colour of the bladder irrigation fluid was closely observed and stopped until the colour was clear. Keep the catheter open after operation to avoid blockage by blood clots and residual prostate tissue. Observe the absence of hematuria for at least one day and then remove the catheter. After removing the catheter, observe and record the patient's urination, arrange for discharge after no obvious abnormality or discomfort on physical examination, and record the length of hospitalization.

Postoperative complications were assessed according to Clavien-Dindo grading criteria [16]. Patients were regularly followed up for postoperative complications, and the incidence of low-grade complications (Clavien-Dindo classification < 3) and high-grade complications (Clavien-Dindo classification ≥ 3) was recorded.

Table 1 Comparison of baseline information

	450 nm DiLVP	1470 nm DiLEP	*P*
Age (years)	74.38 ± 2.93	73.47 ± 3.06	0.088
BMI (kg/m2)	23.97 ± 2.63	24.58 ± 2.08	0.149
Prostate volume (ml)	71.99 ± 18.72	74.47 ± 17.15	0.436
IPSS	26.97 ± 3.31	28.02 ± 3.81	0.098
VSS	11.18 ± 5.63	12.22 ± 5.34	0.286
SSS	7.59 ± 3.75	8.32 ± 3.42	0.252
QoL	4.00 ± 1.40	4.24 ± 1.23	0.305
IIEF-5	18.18 ± 4.21	17.59 ± 4.96	0.469
PSA (ng/ml)	2.95 ± 0.70	2.80 ± 0.78	0.254
Qmax (ml/s)	7.25 ± 1.20	7.17 ± 1.72	0.760
PVR (ml)	118.90 ± 46.97	135.17 ± 50.40	0.061

Statistical analysis

IBM SPSS 27.0 (International Business Machines Corporation, Armonk, New York, USA) statistical software was applied to analyse all data information. Continuous variables were tested for normality, and if they obeyed normal distribution, they were expressed as mean ± standard deviation, and comparisons between two groups were made using the t-test for two independent samples; if they did not obey normal distribution, they were expressed as median ± interquartile spacing, and comparisons between two groups were made using the non-parametric rank sum test (Mann-Whitney U test). Dichotomous variables were expressed as percentages and differences were analysed using the chi-square test. A $P < 0.05$ was used to represent a statistical difference in the data.

Results

Comparison of preoperative baseline data between 1450 nm DiLVP group and 1470 nm DiLEP group

According to the inclusion and exclusion criteria, a total of 128 BPH patients were included and divided into experimental and control groups according to the different surgical methods. The experimental group contains a total of 63 cases in the 450 nm DiLVP group, and the control group contains a total of 65 cases in the 1470 nm DiLEP group. The baseline data of all the patients included in the study are shown in Table 1; Fig. 2. Comparison of the baseline data of the two groups of patients revealed that there was no statistical difference in the baseline characteristics of the patients in the two groups ($P > 0.05$).

Comparison of perioperative indicators between 450 nm DiLVP group and 1470 nm DiLEP group

All 450 nm DiLVP and 1470 nm DiLEP surgeries were successfully completed, and no patients were transferred to open surgery. The perioperative index data of the two groups are shown in Table 2; Fig. 3. Comparison of the perioperative indexes of the two groups revealed that there was a statistical difference between the two groups in terms of surgical time ($P < 0.001$), and compared with the 1470 nm DiLEP group, the 450 nm DiLVP group had a higher surgical efficiency in terms of vaporising hyperplastic prostate tissue. In terms of laser energy consumption ($P < 0.001$), and bladder irrigation time ($P < 0.001$), the 450 nm DiLVP group was lower than the 1470 nm DiLEP group, and the difference was statistically significant. There was no statistically significant difference between the two groups in terms of

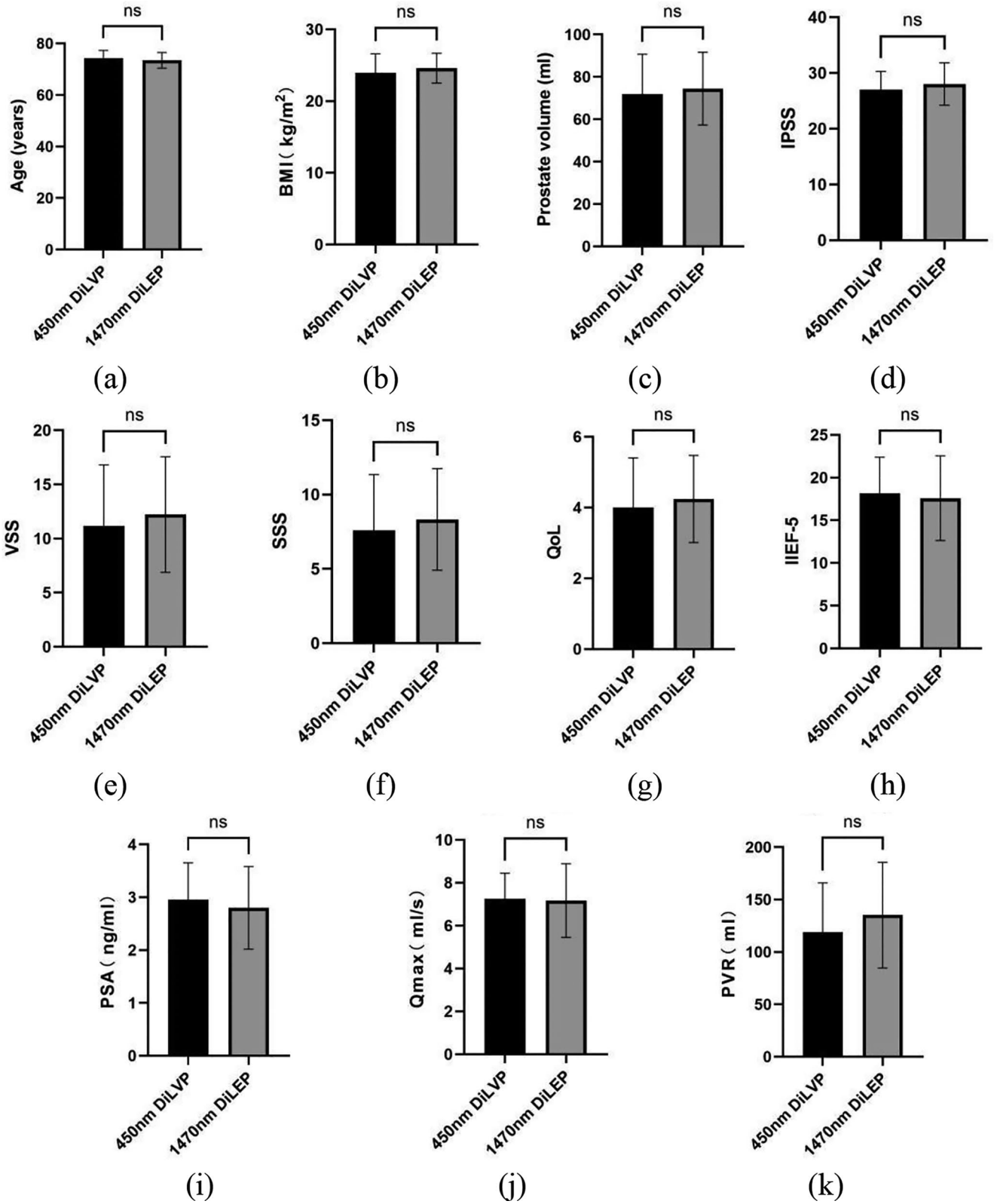

Fig. 2 Comparison of preoperative baseline data between the 450 nm DiLVP group and the 1470 nm DiLEP group. (**a**) Age; (**b**) Body mass index (BMI); (**c**) Prostate volume; (**d**) International prostate symptom score (IPSS); (**e**) Void symptom score(VSS); (**f**) Storage symptom score (SSS); (**g**) Quality of life (QoL); (**h**) International index of erectile function(IIEF-5); (**i**) Prostate specific antigen (PSA); (**j**) Maximum urinary flow rate (Qmax); (**k**) Postvoiding residual bladder volume(PVR). ns: $P > 0.05$, no significance

Table 2 Comparison of perioperative indicators

	450 nm DiLVP	1470 nm DiLEP	*P*
Operation time (min)	45.60 ± 15.35	60.36 ± 12.66	< 0.001
Laser energy consumption (kj)	187.23 ± 42.36	245.86 ± 63.58	< 0.001
Duration of indwelling urinary catheter (d)	1.56 ± 0.86	1.74 ± 0.61	0.176
Bladder irrigation time (h)	18.54 ± 2.61	23.14 ± 4.47	< 0.001
Hospital stay (d)	7.37 ± 1.37	7.88 ± 1.64	0.058
Decrease in haemoglobin (g/dl)	1.53 ± 0.54	1.48 ± 0.76	0.668
Decrease in serum sodium (mmol/l)	2.47 ± 0.93	2.55 ± 1.24	0.680

indwelling catheter time, hospitalisation time, postoperative haemoglobin drop level and serum sodium drop level ($P > 0.05$).

Comparison of surgical efficacy between 450 nm DiLVP group and 1470 nm DiLEP group

The data of postoperative follow-up indexes of the two groups are shown in Table 3; Fig. 4. Analysis of the follow-up indexes revealed that one and three months postoperatively, compared with the preoperative period, the patients who underwent the two surgical methods showed a significant improvement in the subjective perception scores such as the total IPSS, VSS, SSS, and QoL, and in the objective

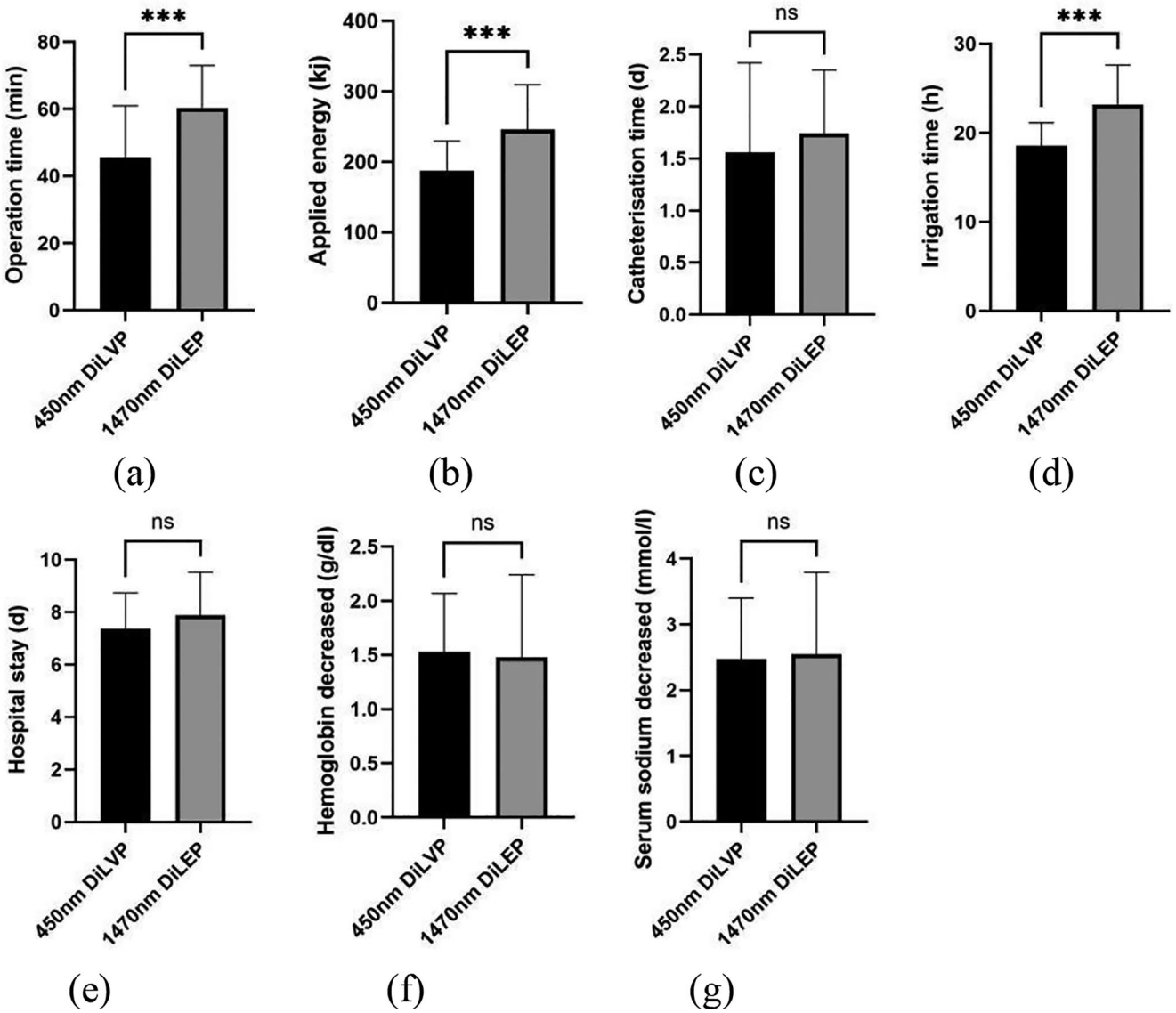

Fig. 3 Comparison of perioperative indicators between the 450 nm DiLVP group and the 1470 nm DiLEP group. (**a**) Operation time; (**b**) Applied energy; (**c**) Catheterisation time; (**d**) Irrigation time; (**e**) Hospital stay; (**f**) Hemoglobin decreased; (**g**) Serum sodium decreased. ns: $P > 0.05$, no significance; ***: $P < 0.001$

Table 3 Comparison of surgical outcome indicators

	Preoperative	1 month postoperatively	3 month post-operatively
IPSS			
450 nm DiLVP	26.97±3.31	25.65±2.36	8.60±1.35
1470 nm DiLEP	28.02±3.81	25.89±2.67	8.54±1.65
P	0.098	0.591	0.822
VSS			
450 nm DiLVP	11.18±5.63	4.35±2.62	3.36±2.15
1470 nm DiLEP	12.22±5.34	4.83±2.35	3.25±2.65
P	0.286	0.278	0.797
SSS			
450 nm DiLVP	7.59±3.75	5.86±3.69	5.26±2.45
1470 nm DiLEP	8.32±3.42	6.14±3.87	5.36±2.53
P	0.252	0.676	0.821
QoL			
450 nm DiLVP	4.00±1.40	2.54±1.63	2.35±1.26
1470 nm DiLEP	4.24±1.23	2.65±1.74	2.53±1.05
P	0.305	0.713	0.382
PSA(ng/ml)			
450 nm DiLVP	2.95±0.70	1.76±0.43	1.43±0.25
1470 nm DiLEP	2.80±0.78	1.82±0.36	1.44±0.33
P	0.254	0.394	0.847
Qmax(ml/s)			
450 nm DiLVP	7.25±1.20	23.58±2.64	24.63±2.31
1470 nm DiLEP	7.17±1.72	23.65±2.13	25.58±2.35
P	0.760	0.869	0.023
PVR(ml)			
450 nm DiLVP	118.90±46.97	22.98±6.35	19.15±6.54
1470 nm DiLEP	135.17±50.40	22.65±5.14	20.35±5.65
P	0.061	0.748	0.269

examination indexes such as the PVR and the PSA level, and that there was no statistically significant difference between the two groups ($P>0.05$). However, we observed a statistically significant difference in Qmax index between the two groups at 3 months postoperatively ($P=0.023$), and compared with the 450 nm DiLVP group, the patients in the 1470 nm DiLEP group had a significant relief of maximal urinary flow rate postoperatively. And there was no statistically significant difference in the Qmax index at 1 month postoperatively between two groups ($P>0.05$).

Comparison of the impact on sexual function between 450 nm DiLVP group and 1470 nm DiLEP group

The degree of impact on sexual function of the patients included in the study was analysed using the IIEF-5 score and the incidence of postoperative sexual function-related complications (retrograde ejaculation, ejaculatory pain, and haematospermia) as the main evaluation indexes. The postoperative sexual function data of the two groups are shown in Table 4, and the differences between the IIEF-5 scores of the two groups at 1 month and 3 months after surgery and the preoperative scores were not statistically significant ($P>0.05$). By comparing the ejaculatory function of the two groups at 1 and 3 months postoperatively, we found that the incidence of retrograde ejaculation at 1 and 3 months postoperatively in the 450 nm DiLVP group was 0% and 7.7%, respectively, and that of retrograde ejaculation at 1 and 3 months postoperatively in the 1470 nm DiLEP group was 4.8% and 9.2%, respectively, and the difference between the two groups was not statistically significant ($P>0.05$); There were no complications such as painful ejaculation and the appearance of haematospermia in both groups after the operation.

Comparison of postoperative complication rates between the 450 nm DiLVP group and the 1470 nm DiLEP group

There were no intraoperative complications such as perforation of the capsula, bladder wall injury and TURS in both groups. The incidence of postoperative complications in the 450 nm DiLVP group and the 1470 nm DiLEP group was assessed in Table 5, according to the Clavien-Dindo grading criteria. A total of 5 cases of patients in the 450 nm DiLVP group developed postoperative complications. Evaluated according to the grading criteria, there were 3 cases (4.8%) of low-grade complications (Clavien-Dindo grading<3) and 2 cases (3.2%) of high-grade complications (Clavien-Dindo grading≥ 3).

A total of 11 patients in the 1470 nm DiLEP group experienced postoperative complications. Assessed according to grading criteria, there were 5 cases (7.7%) of low-grade complications (Clavien-Dindo grading<3) and 6 cases (9.2%) of high-grade complications (Clavien-Dindo grading≥ 3).

Discussion

BPH is a slowly progressive benign prostate disease, and its clinical progressiveness refers to the tendency of BPH patients to have progressive exacerbation of subjective symptoms and objective indicators as the course of the disease prolongs [17]. The currently recognised components of clinical progression of BPH include: decreased quality of life of patients due to exacerbation of LUTS, progressive decrease in Qmax, recurrent haematuria, recurrent urinary tract infections, bladder stones, acute urine retention (AUR)

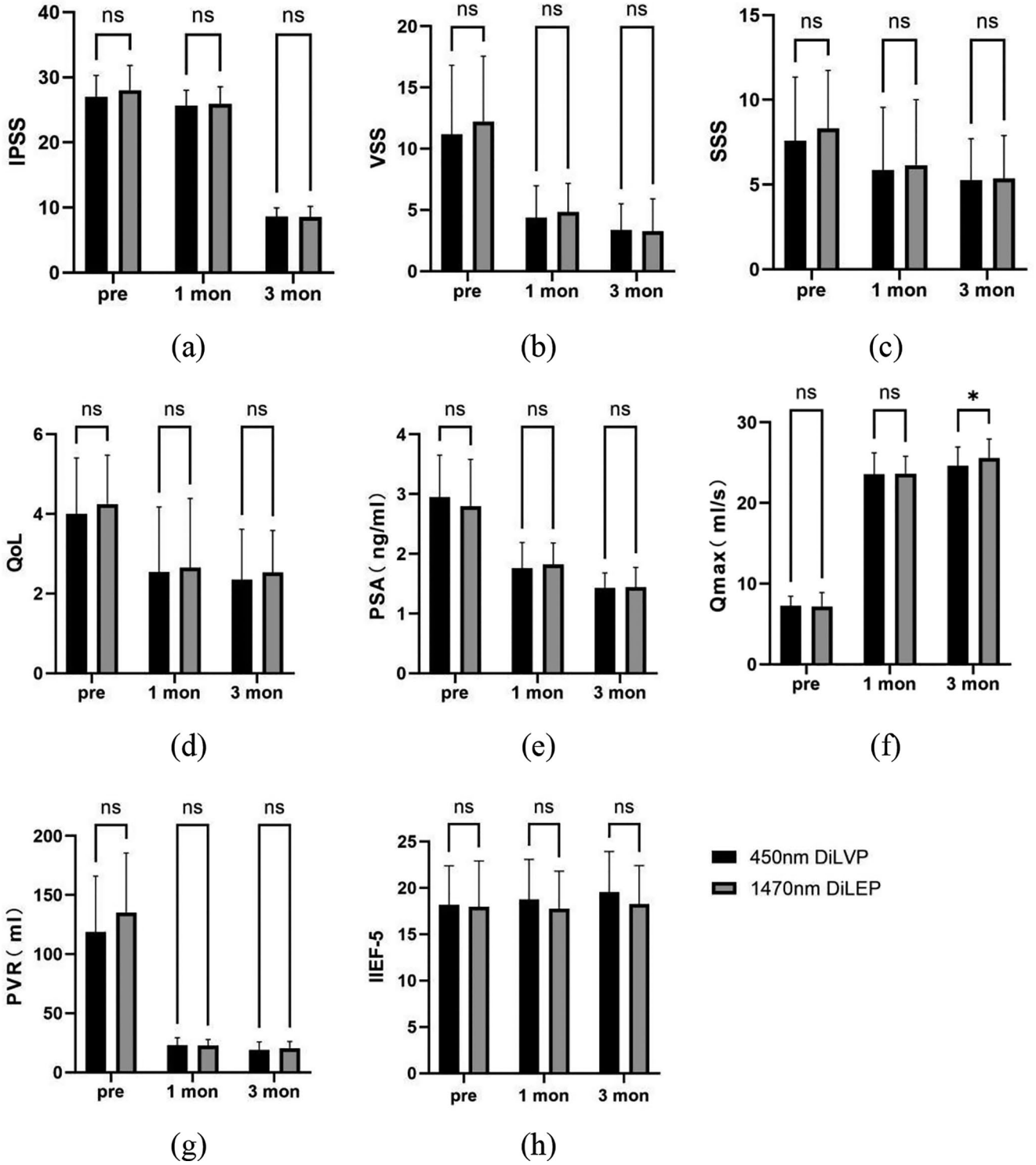

Fig. 4 Comparison of surgical efficacy indexes between 450 nm DiLVP group and 1470 nm DiLEP group. (**a**) International prostate symptom score (IPSS); (**b**) Void symptom score (VSS); (**c**) Storage symptom score (SSS); (**d**) Prostate specific antigen (PSA); (**e**) Maximum urinary flow rate(Qmax); (**f**) Postvoiding residual bladder volume (PVR); (**g**) Quality of life (QoL); (**h**) International index of erectile function(IIEF-5). Pre: preoperative data; 1 mon: data of 1 month postoperatively; 3 mon: data of 3 month postoperatively. ns: $P > 0.05$, no significance; *: $0.01 < P < 0.05$

Table 4 Comparison of sexual function indicators

	Preoperative	1 month postoperatively	3 month postoperatively
IIEF-5			
450 nm DiLVP	18.18±4.21	18.75±4.32	19.56±4.36
1470 nm DiLEP	17.59±4.96	17.76±4.05	18.24±4.17
P	0.469[a]	0.184[a]	0.083[a]
Retrograde ejaculation			
450 nm DiLVP	0	0	3(4.8%)
1470 nm DiLEP	0	5(7.7%)	6(9.2%)
P	-	0.058[b]	0.492[b]

Table note: a: t-test, $p<0.05$ considered statistically significant; b: chi-square test, $p<0.05$ considered statistically significant

Table 5 Comparison of incidence of postoperative complications

	1 month postoperatively	3 month postoperatively
Incontinence		
450 nm DiLVP	1(1.6%)	3(4.8%)
1470 nm DiLEP	3(4.6%)	5(7.7%)
P	0.619	0.718
Urinary tract stricture		
450 nm DiLVP	2(3.2%)	2(3.2%)
1470 nm DiLEP	3(4.6%)	4(6.2%)
P	1.000	0.680
Bladder neck contracture		
450 nm DiLVP	0	0
1470 nm DiLEP	2(3.1%)	2(3.1%)
P	0.496	0.496
Low-grade complications		
450 nm DiLVP	1(3.2%)	3(4.8%)
1470 nm DiLEP	3(4.6%)	5(7.7%)
P	0.619	0.718
High-grade complications		
450 nm DiLVP	2(3.2%)	2(3.2%)
1470 nm DiLEP	5(7.7%)	6(9.2%)
P	0.440	0.274

and renal impairment, and the acceptance of surgical treatment by patients with BPH is the ultimate manifestation of disease progression [18–20].

TURP has been used for the surgical treatment of BPH over the past decade, primarily for the treatment of patients with prostate volumes≤80 mL [6]. However, TURP has some inherent limitations such as TURS, urinary incontinence, bleeding, and retrograde ejaculation, which affect the prognosis of at least 40% of patients with BPH [21, 22]. Therefore, laser surgery deserves further investigation to support its clinical application given the advantages of less bleeding, no TURS, and faster postoperative recovery.

Among the different types of lasers, diode lasers have good safety and effectiveness. The 1470 nm diode laser energy can be absorbed by both haemoglobin and cells, water, with the characteristics of being able to concentrate heat with high precision to deal with small volumes of tissue, penetrating tissue to a depth of 2–3 mm, and having good haemostatic ability [23–25]. And in 2022, 450 nm diode laser treatment machine was first applied to prostate vaporisation surgery in China, which showed superior performance in terms of perioperative indicators such as operation time and bladder irrigation time [26]. A number of clinical studies have now demonstrated that 450 nm DiLVP has the advantages of high vaporisation efficiency, high precision, good coagulation and haemostasis [27, 28].

Therefore, for the first time, our study comprehensively analysed the main outcomes of the comparison of the efficacy of the two surgical approaches by comparing the clinical data of BPH patients who underwent 450 nm DiLVP and 1470 nm DiLEP. We found statistically significant differences between the two groups in terms of perioperative indicators under the condition that there was no significant difference in preoperative baseline data. In terms of operative time, the 450 nm DiLVP group was significantly lower than the 1470 nm DiLEP group, mainly due to the fact that on the one hand, the physical properties of the 450 nm diode laser dictate its higher prostate vapourisation efficiency, which is capable of substantially increasing the speed of surgery. On the other hand, the 450 nm blue laser diode therapy machine is equipped with 980 nm diode laser, which has significant haemostatic effect on arterial bleeding, and intraoperatively ensures that the surgeon operates with a clear field of vision and substantially reduces the unnecessary intraoperative haemostatic time [26, 27].

An in vitro experimental study by Xu et al. [29] exposed four different wavelength lasers at a fixed power and speed, respectively, quasi-exposed to fresh prostate tissue from the same patient, the 450 nm diode laser penetrated the isolated prostate tissue to a significantly higher depth and width. It was confirmed that the 450 nm diode laser was competent to achieve a vaporisation efficiency of prostate tissue that exceeded that of the 1470 nm diode laser, which is in keeping with the findings of our study.

Other perioperative statistics were comparable between the two groups of patients: the 450 nm DiLVP was more effective than the 1470 nm DiLEP in terms of bladder irrigation time, and the superiority in haemostatic effect allowed the 450 nm diode laser to significantly shorten the postoperative bladder irrigation time of its patients, whereas the 1470 nm diode laser's higher heating capacity, the probability of accidental injury was increased [30]; meanwhile, the total energy consumption of the laser in the 1470 nm DiLEP group was greater than that in the 450 nm DiLVP group, which was mainly due to the inequality of the physical mechanism and the type of vapourisation [31, 32].

In terms of postoperative subjective scoring metrics (overall IPSS, VSS, SSS, and QoL) and objective examination metrics (PVR, PSA level) in this study, there was no significant difference between the 450 nm DiLVP group and

the 1470 nm DiLEP group. However, in the 3-month postoperative follow-up, the rise in Qmax in the 1470 nm DiLEP group was statistically significant, suggesting that compared with the 450 nm diode laser, the 1470 nm diode laser was effective in improving the symptoms in the short-term postoperative voiding period. At 3-month postoperative follow-up, several studies [26, 28] have found significant improvement in Qmax in patients after 450 nm DiLVP, but currently there are few clinical studies with long-term follow-up to support a durable conclusion. Therefore, for the reason of the significant short-term Qmax improvement we hypothesise that this is due to the large opening structure provided by 1470 nm diode laser enucleation in the prostatic urethra, which allows for a sustained improvement in maximal urinary flow rate.

In addition, detrusor underactivity (DU) secondary to long-term BPH is also an important factor contributing to the lack of effective relief of patients' postoperative voiding period symptoms. According to clinical comparative study with 3-year postoperative follow-up [33], in BPH patients with severe DU, laser surgery showed low improvement in voiding symptoms, quality of life, urinary flow rate, and bladder voiding efficiency (BVE), and multicentre clinical controlled studies are still needed in the future to confirm the adverse effect of DU on the prognosis of BPH surgery.

In this study, it was found that there was no significant difference between the two groups in terms of postoperative erectile function score and the incidence of sexual dysfunction complications such as retrograde ejaculation. In contrast, the 450 nm DiLVP group performed relatively better in terms of improvement in postoperative erectile function score, but there was no significant difference. The possible reason lies in the high vaporisation efficiency and resection depth of 450 nm diode laser, if the resection depth is completely deep into the capsula of the prostate, it is inclined to cause perforation of the capsula and serious intra-operative complications, which to a certain extent restricts the operating space of the surgeon, so that it can be able to basically preserved for the peritoneal nerves related to sexual function.

Mykoniatis et al. [34] pointed out that minimally invasive surgery for prostatic hyperplasia will affect the patient's erectile function, because of the perforation of the capsula of the prostate occurring during the operation of the electrocutaneous or laser equipment to directly damage the neurovascular bundles, or its thermal penetration effect indirectly damages the neurovascular bundles outside the peritoneum. Meanwhile, the 1470 nm DiLEP procedure has a relatively large operating space, while it is easy to cause accidental injury to the prostate peritoneal nerves.

According to recent studies, another advantage of 450 nm DiLVP over other prostate laser procedures is the maintenance of sexual function. In 2023, Man C et al. [27], after retrospectively studying the data of 20 patients with modified 450 nm DiLVP in single centre, concluded that the modified 450 nm diode laser prostate vaporisation was recommended for BPH patients with the demand for sexual life. It was able to achieve the therapeutic goal of preserving sexual function while improving urinary symptoms in patients with BPH, and all 20 patients had good ejaculatory function after the procedure, with no retrograde ejaculation.

The outcomes of meta-analysis [35] showed that the impact of surgical treatment of BPH on patients' sexual function was mainly focused on ejaculatory function, and retrograde ejaculation was the most common. The incidence of retrograde ejaculation may be reduced along with the precision of minimally invasive surgical equipment, while most of the endo-prostatectomy treatments did not have a significant negative impact on patients' erectile function.

In the present study, we found no statistical difference between the two groups in terms of low-grade complications, high-grade complications and total complication incidence in the 450 nm DiLVP group compared to the 1470 nm DiLEP group. However, advantages in terms of the incidence of single complication emerged, for instance, when analysing the incidence of bladder neck contracture, none of the 450 nm DiLVP group, while two cases of bladder neck contracture occurred in the 1470 nm DiLEP group, with an incidence rate of 3.1%.

Bladder neck contracture is a relatively common long-term complication after prostate enlargement surgery, and its pathogenesis is still unclear, mainly related to the size of the prostate, surgical time, electrocoagulation haemostasis time, depth and scope of surgical incision, and other factors, which need to be further explored in the correlation between laser prostate vapour resection and bladder neck contracture [36, 37]. He Y et al. [38] indicated that the use of 450 nm semiconductor laser combined with hormone treatment of bladder neck contracture could achieve the therapeutic goals of adequate vapor dissection of the bladder neck and prevention of scar tissue formation, and the results of the 3-month postoperative follow-up were satisfactory, but its long-term effects need to be further verified.

This study provided a comprehensive comparison of the effectiveness and safety of two surgical procedures, 450 nm DiLVP and 1470 nm DiLEP, but there are still shortcomings and limitations. On the one hand, the study was single-centre study, and the volume of patients included was relatively limited and somehow lacked universality; on the other hand, due to the restricted sample size, without performing further subgroup analyses based on variables such as prostate volume, age, and urethral contractility. Additionally, the longest observation of recovery of urinary control function in this study was 3 months after surgery, however

the lack of comparisons of recovery in long term could have an impact on conclusions about the safety and efficacy of the procedure. Comprehensive controlled studies in long-term large-sample multicentre clinical trials are still needed in the future to draw more general clinical conclusions.

Conclusion

In terms of perioperative indicators, compared with 1470 nm DiLEP, 450 nm DiLVP shows high surgical efficiency in operative time, bladder irrigation time, and with low laser energy consumption;

In terms of postoperative follow-up indicators, both 450 nm DiLVP and 1470 nm DiLEP procedures significantly improved the symptoms of BPH patients with similar efficacy. In the long term, the 1470 nm DiLEP procedure improved the maximal urinary flow rate of BPH patients more significantly, which still needs to be further verified by large-sample clinical studies in the future.

Author contributions Longyang Zhang and Qingfei Xing have given substantial contributions to the conception of the manuscript, Zhichao Wang and Xinghua Gao to the acquisition, analysis and interpretation of the data. Zhichao Wang and Mengzhen Qiu have participated to drafting the manuscript, Longyang Zhang revised it critically. All authors read and approved the final version of the manuscript.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethical approval In accordance with the Declaration of Helsinki (2013 version), the study was approved by the Ethics Committee of Jinan Central Hospital, and informed consent was obtained from all human participants.

Competing interests The authors declare no competing interests.

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