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Comparison of the efficacy and safety of transurethral laser versus open prostatectomy for patients with large-sized benign prostatic hyperplasia: A meta-analysis of comparative trials

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Purpose: The selection of open prostatectomy (OP) over transurethral laser surgery is controversial for large volume prostates. Thus, we aim to compare the efficacy and safety of transurethral laser versus OP, and provide the latest evidence of clinical practice for large-sized benign prostatic hyperplasia (BPH).

Materials and Methods: This meta-analysis used Review Manager V5.3 software and the systematic literature search of Cochrane Library, Embase, PubMed, and Web of Science datasets was performed for citations published from 2000 to 2020 that compared transurethral laser with OP for the treatment of large BPH. Variables of interest assessing the two techniques included clinical characteristics, and the perioperation-, effectiveness-, and complication-related outcomes.

Results: The meta-analysis included twelve studies containing 1,514 patients, with 792 laser and 722 OP. The transurethral laser group was associated with shorter hospital stay and catheterization duration, and less hemoglobin decreased in the perioperative variables. There was no significant difference in the international prostate symptom score, post-void residual urine volume, maximum flow rate, and quality of life score. Transurethral laser group had a significantly lower incidence of blood transfusion than OP group (odds ratio, 0.10; 95% confidence interval, 0.05 to 0.19; $p<0.001$; $I^2=8\%$), and no statistical differences were found with respect to the other complications.

Conclusions: Both OP and transurethral laser prostatectomy are effective and safe treatments for large prostate adenomas. With these advantages of less blood loss and transfusion, and shorter catheterization time and hospital stay, laser may be a better choice for large BPH.

Keywords: Laser therapy; Meta-analysis; Prostatectomy; Prostatic hyperplasia; Transurethral resection of prostate

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INTRODUCTION

Benign prostatic hyperplasia (BPH) is a chronic, progressive disease for elderly men. For patients over 70 years old, up to 4% have a prostatic volume more than 100 mL [1]. For some of patients with large BPH, surgical intervention is required when drug treatment (alpha-blockers, anticholinergics, etc. alone or combinations) is not effective. In addition, surgical intervention should also be considered for large-prostate patients who have moderate-to-severe lower urinary tract symptoms (LUTS) or who have complications from bladder outlet obstruction (BOO) due to BPH (renal insufficiency due to BOO, recurrent urinary tract infection [UTI], repeated gross hematuria, bladder stones, one or more episodes of urinary retention, etc.). Until recently, open prostatectomy (OP) has been considered for decades as the gold standard procedures for prostates larger than 80 mL [2,3]. However, OP brings considerable surgery-related complications, including more intraoperative bleeding, longer catheterization time and longer hospitalization [4]. Thus, more methods emerge endlessly, such as prostatic artery embolization, robot-assisted simple prostatectomy and transurethral laser surgery in managing large BPH [2,5].

Since holmium laser was initially reported for endoscopic resection of prostate in 1996 by Gilling et al. [6], transurethral laser surgery has become increasingly a popular option for the management of bothersome LUTS. The types of lasers have been a growing tendency to diversification and versatility for the treatment of BPH, and surgical approach has also been diversified (vaporization, resection, and enucleation, alone or combinations) recently. With the accumulation of surgical experience and proficiency in surgical techniques, the indications for transurethral laser prostatectomy have also expanded from conventional-volume to large-volume prostates. The efficacy and safety of transurethral laser prostatectomy compared with OP for patients with large prostates has been proven by several studies [2,7-10].

With the development of laser technology and the improvement of surgical methods, the proportion of laser surgery for BPH is also increasing. Nevertheless, it remains debatable whether transurethral laser prostatectomy can replace OP as the gold standard of treatment for large prostates. Published studies on comparing these two surgical methods are still limited, especially for large BPH [11-15]. So we made this meta-analysis comparing the efficacy and safety of transurethral laser surgery and OP to provide the latest evidence of clinical practice for surgical treatment of large-volume prostates.

MATERIALS AND METHODS

The protocol was registered in the 'International prospective register of systematic reviews' (https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42021267469).

1. Search strategy

A bibliographic online search was from January 1, 2000 to December 31, 2020 on Cochrane Library, Embase, PubMed, and Web of Science databases, which compared two surgical methods (transurethral laser prostatectomy vs. OP) with the MESH search terms: "benign prostatic hyperplasia," "laser therapy," and "prostatectomy". No language restriction was applied. We modified search strategy according to the requirements of each online database, and used "related articles" function to broaden online search.

2. Inclusion criteria and exclusion criteria

The certain criteria were defined ahead of search. The comparative trials that met the following inclusion criteria were included: (1) the literatures compared transurethral laser prostatectomy and OP; (2) enrolled patients with LUTS secondary to BPH preoperatively; (3) included OP performed by a traditional open approach (not robotic or laparoscopic); and (4) provided at least one indicator for analysis, such as hemoglobin decline, operation time, catheterization duration, hospital stay, micturition parameters, and the complications.

There were three exclusion criteria were used: (1) included prostate volumes less than 70 mL and did not mention a large prostate; (2) no parameters for comparative analysis in the results; (3) enrolled patients with vesical calculus, urethral stricture, or previous prostate surgery.

3. Data extraction

Two reviewers (H.B.W. and B.Y.G.) independently screened and evaluated the following parameters: (1) general data: journal, first author, year of publication, study design, study quality, number of patients, age of the patients, and prostate size; (2) perioperative variables: hemoglobin decline, operative time, catheterization time, and hospital stay; (3) effectiveness-related outcomes during the follow-up period: International Prostate Symptom Score (IPSS), maximum flow rate (Qmax), postvoid residual (PVR), quality of life score (QoL), and length of follow-ups; (4) surgical complications: blood transfusion rate, transitory urge incontinence, stress incontinence, bladder neck/urethral stenosis, UTI, surgical intervention for bleeding, and acute urinary retention (AUR).

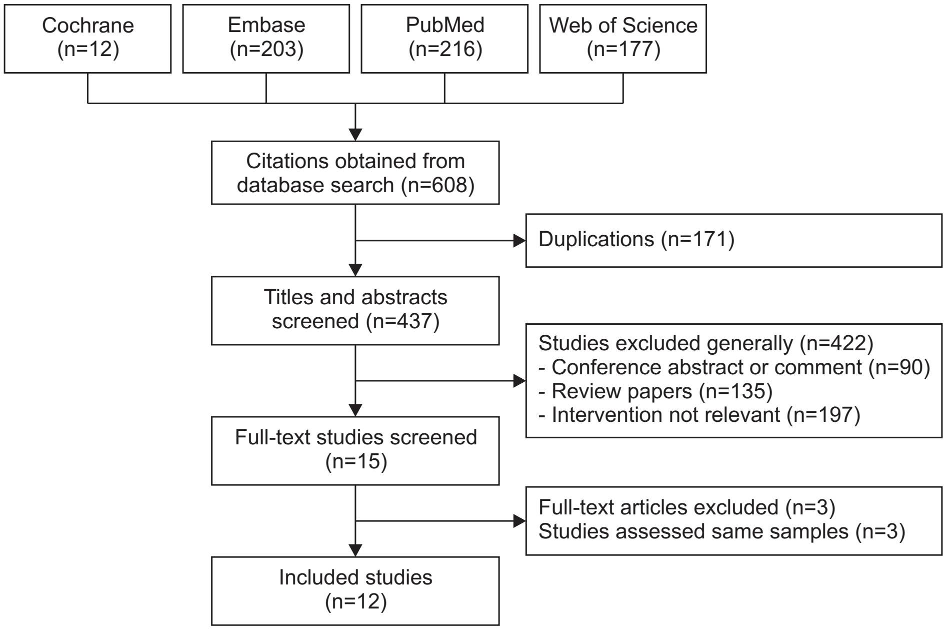

Fig. 1. Flow diagram of studies identified, included, and excluded from the analysis.

4. Assessment of study quality

Jadad composite scale and Newcastle–Ottawa scale were used to score the methodological quality of the included randomized controlled trials (RCTs) and non-RCTs, respectively. The Newcastle–Ottawa scale was used to assess the quality of the initial design, content and ease of use. The score of each individual study quality was from 0 to 9 according to the star system of Newcastle–Ottawa scale. This procedure was independently performed by Y.F.T. and W.Z., and disagreements were resolved by D.H.Z.

5. Statistical analysis and meta-analysis

The data was calculated by using Review Manager V5.3 software (Cochrane Collaboration, Oxford, UK). Transurethral laser surgery was regarded as the experimental intervention, and the other group was regarded as the control intervention. Dichotomous variables and continuous variables were represented as odds ratio (OR) and weighted mean difference (WMD), with 95% confidence interval (CI). Heterogeneity was evaluated by the chi-squared test and p-value [16]. A fixed-effects model was applied to pool the results, and there was no evident heterogeneity if $p>0.1$ or $I^2<50\%$, otherwise, a random effects model was applied. Considering the limitations of the Cochrane software, we used corresponding statistical method to convert median and interquartile range into mean and standard deviation [17,18]. A subgroup analysis of RCTs and non-randomised studies of the effects of interventions (NRSIs), was applied to probe possible discrepancies between groups. We also conducted subgroup meta-analyses of perioperative variables on the type of surgical technology: enucleation and non-enucleation. Two-sided tests with $p<0.05$ were considered to be statistically significant.

RESULTS

1. Study characteristics

As shown in Fig. 1, a total of 608 articles were preliminarily retrieved through electronic search, and 12 studies were enrolled finally [2,8,19-28]. The characteristics of the enrolled studies are shown in Table 1, which includes 5 RCTs and 7 non-RCT studies (792 patients in the transurethral laser group and 722 patients in the OP group). One study was excluded due to lack of data available for analysis [29]. Through full-text analysis, the other 3 articles were considered to be the same study with different follow-up points, and consolidated data was analyzed with enrolled corresponding articles [30-32].

2. Outcomes of perioperative variables

No significant difference was observed in operative time (WMD, 5.71; 95% CI, -8.36 to 19.77; p=0.43; $I^2=97\%$), and resected prostatic weight (WMD, -2.37; 95% CI, -11.82 to 7.07; p=0.62; $I^2=86\%$). The experimental intervention group was associated with shorter hospital stay (WMD, -4.68; 95% CI, -5.51 to -3.86; $p<0.001$; $I^2=96\%$), shorter catheterization duration (WMD, -4.01; 95% CI, -4.91 to -3.10; $p<0.001$; $I^2=99\%$), and less hemoglobin decreased (WMD, -1.15; 95% CI, -1.43 to -0.87; $p<0.001$; $I^2=0\%$). Regarding the subgroup analysis of enucleation and non-enucleation, the perioperative variables had no obvious change compared with the overall analysis. These outcomes

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Table 1. Preoperative characteristics of clinical trials included in the meta-analysis

Study (reference)	Year	Follow-up months	Publication type	Surgical type	No. of patients	Age (y)	Qmax (mL/s)	PSA (ng/mL)	QoL	IPSS	Prostate size (g)
Moody and Lingeman [23]	2001	3, 20	Non-RCT	Holep	10	74.8±3.6	NA	NA	NA	19±2.6	>100
				OP	10	71.1±1.3	NA	NA	NA	22.4±3.3	>100
Naspro et al. [28]	2006	1, 3, 12, 24	RCT	Holep	41	66.26±6.55	7.83±3.42	6.33±3.43	4.07±0.93	20.11±5.84	113.27±35.33
				OP	39	67.27±6.72	8.32±2.37	6.99±4.28	4.44±0.96	21.60±3.24	124.21±38.52
Salonia et al. [27]	2006	NA	RCT	Holep	34	67.4±6.7	8.9±4.2	8.0±8.4	4.6±1.0	19.6±7.0	113.8±37.0
				OP	29	68.0±6.4	8.4±2.4	7.2±4.7	4.4±1.0	21.6±3.5	121.0±34.9
Zhang et al. [26]	2007	3	RCT	Holep	32	72.1±6.3	6.1±2.9	NA	4.7±1.2	27.4±5.5	139.6±26.4
				OP	28	75.7±5.1	6.7±2.8	NA	4.6±1.0	25.1±6.4	157.2±35.1
Kuntz et al. [24]	2008	1, 3, 6, 12, 18, 24, 36, 48, 60	RCT	Holep	60	69.2±8.4	3.8±3.6	NA	NA	22.1±3.3	114.6±21.6
				OP	60	71.2±8.3	3.6±3.8	NA	NA	21.0±3.6	113.0±19.2
Alivizatos et al. [25]	2008	1, 3, 6, 12, 18	RCT	PVP	65	74 (67–80)	8.6 (6.7–10.5)	6.2 (3.1–8.44)	3 (2–4)	20 (15–22)	93 (85–100)
				OP	60	67.5 (65–74)	8 (5.8–10.2)	6.3 (2.9–8.6)	3 (2.25–4)	21 (16.25–23.75)	96 (86.2–100)
Elshal et al. [22]	2016	1, 3, 12, 24	Non-RCT	Holep	92	67.7±6.9	NA	9.4 (0.5–43)	NA	NA	166.7±49.7
				OP	91	68.3±7.1	NA	9.8 (0.2–57)	NA	NA	161.4±35.7
Lanchon et al. [21]	2018	28 (PVP) 35 (OP)	Non-RCT	PVP	57	77±9	NA	7.3±5.4	4±1	18±6	103±25
				OP	54	74±9	NA	10.1±7.9	4±1	20±7	142±58
Misraï et al. [8]	2018	1, 2, 6	Non-RCT	GreenLEP	204	68 (65–73)	NA	5 (3.2–8.5)	NA	NA	100 (80–120)
				OP	204	69 (64–76)	NA	5.9 (3.7–9)	NA	NA	90 (80–120)
Rosenhammer et al. [20]	2018	NA	Non-RCT	Holep	72	69.9±7.9	NA	7.32±4.37	NA	NA	112.9±25.8
				OP	72	70.8±6.6	NA	7.36±4.36	NA	NA	112.6±21.2
Enikeev et al. [19]	2019	3, 6	Non-RCT	ThuFlep	90	67.4±7.7	7.5±1.9	NA	3.9±0.8	21.8±1.1	127.8±40.2
				OP	40	67.0±1.0	7.9±2.8	NA	4.5±1.5	24.6±3.3	114.1±38.9
Nestler et al. [2]	2019	NA	Non-RCT	ThuVEP	35	71.2 (65.1–74.8)	NA	NA	4.2 (3–5)	20 (18–23)	90.8 (73–121)
				OP	35	70.6 (66.1–74.3)	NA	NA	5 (5–6)	23 (21–25)	95 (84–132)

Values are presented as number only, mean±standard deviation, or median (interquartile range).
OP, open prostatectomy; Qmax, maximum flow rate; PSA, prostate-specific antigen; QoL, quality of life score; IPSS, International Prostate Symptom Score; RCT, randomized controlled trial; Holep, holmium laser enucleation of prostate; NA, not available; PVP, photoselective vaporization of the prostate; GreenLEP, green laser enucleation of the prostate; ThuFLEP, thulium fiber laser enucleation of the prostate; ThuVEP, thulium vapoenucleation of prostate.

Table 2. Overall analysis of perioperative variables comparing transurethral laser with OP

Perioperative outcome	Study	No. of patients (laser/OP)	WMD (95% CI)	p-value	Study heterogeneity				Favors
					χ^2	df	I^2 (%)	p-value	
Operative time									
Total	[2,8,19,21,23-28]	628/559	5.71 (-8.36 to 19.77)	0.43	343.16	9	97	<0.001	None
RCT	[24-28]	232/216	27.49 (16.54 to 38.44)	<0.001*	34.52	4	88	<0.001	OP
NRSI	[2,8,19,21,23]	396/343	-14.71 (-25.78 to -3.65)	<0.001*	36.88	4	89	<0.001	Laser
Enucleation	[2,8,19,23,24,26-28]	506/445	2.92 (-13.12 to 18.96)	0.72	213.77	7	97	<0.001	None
Non-enucleation	[21,25]	122/114	16.34 (-7.41 to 40.08)	0.18	26.63	1	96	<0.001	None
Hemoglobin decrease									
Total	[2,22,24,25,28]	293/285	-1.15 (-1.43 to -0.87)	<0.001*	3.91	4	0	0.42	Laser
RCT	[24,25,28]	166/159	-0.97 (-1.31 to -0.64)	<0.001*	0.13	2	0	0.94	Laser
NRSI	[2,22]	127/126	-1.58 (-2.10 to -1.07)	<0.001*	0.00	1	0	0.96	Laser
Enucleation	[2,22,24,28]	228/225	-1.19 (-1.50 to -0.87)	<0.001*	3.67	3	18	0.30	Laser
Non-enucleation	[25]	65/60	-1.02 (-1.63 to -0.41)	0.001*	NA	NA	NA	NA	Laser
Resected prostate weight									
Total (Enucleation)	[2,8,19,20,22-24,26-28]	670/608	-2.37 (-11.82 to 7.07)	0.62	65.60	9	86	<0.001	None
RCT	[24,26-28]	167/156	-10.24 (-16.54 to -3.93)	0.001*	7.29	3	59	0.06	Laser
NRSI	[2,8,19,20,22,23]	503/452	-1.68 (-5.54 to 2.19)	0.40	53.16	5	91	<0.001	None
Catheterization day									
Total	[2,8,19,21,22,24-28]	710/640	-4.01 (-4.91 to -3.10)	<0.001*	664.82	9	99	<0.001	Laser
RCT	[24-28]	232/216	-3.67 (-5.60 to -1.75)	0.0002*	458.40	4	99	<0.001	Laser
NRSI	[2,8,19,21,22]	478/424	-4.30 (-5.21 to -3.38)	<0.001*	126.87	4	97	<0.001	Laser
Enucleation	[2,8,19,22,24,26-28]	588/526	-4.14 (-5.21 to -3.07)	<0.001*	662.86	7	99	<0.001	Laser
Non-enucleation	[21,25]	122/114	-3.62 (-4.41 to -2.83)	<0.001*	1.96	1	49	0.16	Laser
Hospital stay									
Total	[2,8,19,21-28]	720/650	-4.68 (-5.51 to -3.86)	<0.001*	274.35	10	96	<0.001	Laser
RCT	[24-28]	232/216	-3.97 (-4.22 to -3.72)	<0.001*	200.50	4	98	<0.001	Laser
NRSI	[2,8,19,22,23]	488/434	-4.43 (-4.56 to -4.29)	<0.001*	63.59	5	92	<0.001	Laser
Enucleation	[2,8,19,22,24,26-28]	598/536	-4.98 (-5.97 to -3.98)	<0.001*	260.16	8	97	<0.001	Laser
Non-enucleation	[21,25]	122/114	-3.59 (-4.00 to -3.18)	<0.001*	0.75	1	0	0.39	Laser

OP, open prostatectomy; WMD, weighted mean difference; CI, confidence interval; RCT, randomized controlled trial; NRSI, non-randomised studies of the effects of intervention; NA, not available.
*Statistically significant results (p<0.05).

of perioperative variables are shown in Table 2.

3. Effectiveness-related outcomes during the follow-up period

The micturition parameters at 1 month, 3 months, 6 months, and 12 months postoperatively were collected and combined (Table 3). There were no significant differences between the transurethral laser and OP groups in postoperative IPSS, QoL, Qmax, and PVR in the follow-up periods. At 6 months postoperatively, the pooled Qmax of RCT group was statistically different, while the other parameters of subgroups showed no obvious change compared with the overall analysis.

4. Complications

The transurethral laser group had a significantly lower incidence of blood transfusion than the OP group (OR, 0.10; 95% CI, 0.05 to 0.19; p<0.001; I^2=8%). No statistical differences were found with respect to UTI, stress incontinence, AUR, bladder neck/urethral stenosis, and surgical intervention for bleeding (Table 4). As for subgroup analysis, the complication of AUR in NRSI group was statistically different (OR, 1.93; 95% CI, 0.61 to 6.10; p=0.26; I^2=53% [RCT: OR, 1.06; 95% CI, 0.26 to 4.22; p=0.94; studies=2/4; I^2=51%, NRSI: OR, 4.53; 95% CI, 1.24 to 16.52; p=0.02; studies=2/4; I^2=0%]), while the other indicators of subgroups had no obvious change compared with the overall analysis.

5. Sensitivity analysis, bias analyses, and quality assessment

According to our previous results, there were 2 low-quality RCTs and 3 high-quality RCTs according to the Jadad

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Table 3. Overall analysis of postoperative efficacy comparing transurethral laser with OP

Postoperative outcome	Study	No. of patients (laser/OP)	WMD (95% CI)	p-value	Study heterogeneity				Favors
					χ^2	df	I^2 (%)	p-value	
IPSS									
1 month (RCT)	[24,25,28]	163/152	0.50 (-0.94 to 1.93)	0.50	8.72	2	77	0.01	None
3 months (RCT)	[24-26,28]	192/177	0.33 (-0.25 to 0.91)	0.27	2.67	3	0	0.44	None
6 months									
Total	[8,19,24,25]	413/240	-0.16 (-0.47 to 0.15)	0.31	0.40	3	0	0.94	None
RCT	[24,25]	119/110	-0.22 (-1.11 to 0.67)	0.62	0.19	1	0	0.66	None
NRSI	[8,19]	294/130	-0.15 (-0.49 to 0.18)	0.37	0.19	1	0	0.66	None
12 months (RCT)	[24,25,28]	154/140	0.29 (-0.34 to 0.91)	0.37	0.03	2	0	0.99	None
Qmax (mL/s)									
1 month (RCT)	[24,25,28]	163/152	0.45 (-0.56 to 1.45)	0.38	1.24	2	0	0.54	None
3 months (RCT)	[24-26,28]	192/182	0.76 (-0.19 to 1.71)	0.12	4.09	3	27	0.25	None
6 months									
Total	[8,19,24,25]	413/240	0.63 (-0.63 to 1.89)	0.32	11.75	3	74	0.008	None
RCT	[24,25]	119/110	1.71 (0.05 to 3.37)	0.04*	1.76	1	43	0.18	OP
NRSI	[8,19]	294/130	-0.20 (-1.62 to 1.21)	0.78	3.89	1	74	0.05	None
12 months (RCT)	[24,25,28]	154/140	-0.44 (-2.58 to 1.69)	0.69	5.17	2	61	0.08	None
QoL									
3 months (RCT)	[25,26,28]	138/127	0.07 (-0.28 to 0.43)	0.69	13.76	2	85	0.001	None
PVR (mL)									
3 months (RCT)	[24-26]	151/138	-0.79 (-7.91 to 6.32)	0.83	5.53	2	64	0.06	None

OP, open prostatectomy; WMD, weighted mean difference; CI, confidence interval; IPSS, International Prostate Symptom Score; RCT, randomized controlled trial; NRSI, non-randomised studies of the effects of intervention; Qmax, maximum flow rate; QoL, quality of life score; PVR, postvoid residual volume.
*Statistically significant results (p<0.05).

scale [33]. Sensitivity analysis was performed using 3 high-quality RCTs, and the corresponding results were shown in Table 5. There was no obvious change except for the operative time (WMD, 28.85; 95% CI, 14.01 to 43.69; p=0.0001; I^2=93%), and Qmax (WMD, 1.49; 95% CI, 0.40 to 2.57; p=0.007; I^2=43%) at 6 months postoperatively. Most indicators were stable, which was consistent with the overall analysis. We used funnel plot to evaluate publication bias of enrolled articles in this meta-analysis. Taking prostate volume as an example, no obvious asymmetry was shown in the funnel plot (Fig. 2). Table 6 summarized the quality assessment of enrolled non-RCTs. The Newcastle–Ottawa scale scores from zero to nine stars. For included non-RCTs, 6 studies were of a high quality with a score of eight to nine stars.

DISCUSSION

Since OP was initially reported by Eugene Fuller in 1894, this open surgical approach had been used for more than a hundred years [34]. While OP retrieves great prostatic volume and has the advantage of a short operative time, it is always considered as the gold standard for surgical treatment with prostates larger than 80 g [13]. However, OP is still considered to associate with significant postoperative complications and mortality [24,28,35]. Therefore, in the past three decades, new minimally invasive surgical methods were developed by engineers and surgeons, and expected to replace traditional OP for large BPH patients.

At present, transurethral laser prostatectomy is applied in clinical, including holmium laser, green laser, and thulium laser for pursuing a much better efficacy and safety [11]. For example, transurethral holmium laser enucleation has been proven to be a size-independent method for surgical treatment of LUTS/benign prostatic obstruction in prostates ≥30 cc currently, and postoperative functional outcomes and Clavien–Dindo grade ≥II complications show no difference between all sizes [36]. Therefore, transurethral laser prostatectomy has gradually occupied a certain proportion in the surgical treatment of different sizes prostates. However, it comes to clinical dispute when faced with treatment of large prostates with refractory LUTS. How to choose a more suitable surgical method for BPH with large prostates is difficult but be of great importance, and it is worthy of comparing transurethral laser prostatectomy and OP for large-sized prostates. In our previous meta-analysis, transurethral laser prostatectomy was proven to be an ap-

Table 4. Overall analysis of complications comparing transurethral laser with OP

Complication	Study	No. of patients (laser/OP)	OR (95% CI)	p-value	Study heterogeneity				Favors
					χ^2	df	I^2 (%)	p-value	
Urinary tract infection									
Total	[19,21,22,25]	304/245	0.94 (0.51 to 1.73)	0.85	5.15	3	42	0.16	None
RCT	[25]	65/60	0.75 (0.33 to 1.72)	0.50	NA	NA	NA	NA	None
NRSI	[19,21,22]	239/185	1.23 (0.49 to 3.08)	0.65	4.96	2	60	0.08	None
Transitory urge incontinence									
Total	[19,23,28]	141/89	0.53 (0.25 to 1.10)	0.09	0.86	2	0	0.65	None
RCT	[28]	41/39	0.67 (0.27 to 1.66)	0.39	NA	NA	NA	NA	None
NRSI	[19,23]	100/50	0.32 (0.09 to 1.14)	0.08	0.00	1	0	0.97	None
Stress incontinence									
Total	[8,19,21,23,25,26,28]	499/358	1.61 (0.91 to 2.85)	0.10	4.28	6	0	0.64	None
RCT	[25,26,28]	138/127	1.56 (0.46 to 5.30)	0.48	0.25	2	0	0.88	None
NRSI	[8,19,21,23]	361/231	-0.15 (-0.49 to 0.18)	0.14	4.03	3	26	0.26	None
Acute urinary retention									
Total	[19,21,25,28]	220/207	1.93 (0.61 to 6.10)	0.26	6.39	2	53	0.09	None
RCT	[25,28]	106/99	1.06 (0.26 to 4.22)	0.94	2.03	1	51	0.15	None
NRSI	[19,21]	114/108	4.53 (1.24 to 16.52)	0.02*	0.20	1	0	0.66	OP
Blood transfusion									
Total	[2,8,19,21,22,24,25,28]	644/583	0.10 (0.05 to 0.19)	<0.001*	7.57	7	8	0.37	Laser
RCT	[24,25,28]	166/159	0.10 (0.03 to 0.35)	0.0003*	1.49	2	0	0.47	Laser
NRSI	[2,8,19,21,22]	294/130	-0.15 (-0.49 to 0.18)	<0.001*	6.08	4	34	0.19	Laser
Surgical intervention for bleeding									
Total	[19,21,22,24]	289/229	0.86 (0.30 to 2.51)	0.79	1.01	3	0	0.80	None
RCT	[24]	50/44	0.87 (0.17 to 4.56)	0.87	NA	NA	NA	NA	None
NRSI	[19,21,22]	239/185	0.86 (0.21 to 3.46)	0.83	1.01	2	0	0.60	None
Bladder neck/urethral stenosis									
Total	[8,21,23,24,25,26,28]	462/367	0.61 (0.31 to 1.21)	0.16	3.89	6	0	0.69	None
RCT	[24,25,26,28]	191/176	0.92 (0.37 to 2.26)	0.85	0.00	3	0	>0.999	None
NRSI	[8,21,23]	271/191	0.35 (0.12 to 1.04)	0.06	2.08	2	4	0.35	None

OP, open prostatectomy; OR, odds ratio; CI, confidence interval; RCT, randomized controlled trial; NRSI, non-randomised studies of the effects of intervention; NA, not available.
*Statistically significant results (p<0.05).

propriate treatment for large prostates with the advantages of less intraoperative blood loss, and shorter postoperative catheterization time and hospital stay [33]. However, there were two limitations in the previous study. On one hand, the number of enrolled studies and the sample size were small (5 studies and 448 cases). On the other hand, all the studies of previous result were carried out twelve years ago, and there might be a certain bias due to lack of studies in the last 5 years. The published meta-analysis needs to be updated, and transurethral bipolar enucleation needs to be eliminated to avoid potential bias [12]. Built on previous work of us and Lin, new meta-analysis included recent studies with larger sample sizes is very necessary to resolve this clinical dispute of large prostates [12,33].

Twelve studies were enrolled in the current analysis, and the relevant outcomes were appraised carefully. Transurethral laser surgery was considered to have various advantages over OP in terms of blood loss, hospital stay, and catheterization days, while there was no significant difference was observed in resected prostate weight (p=0.62) and operative time (p=0.43). In the previous meta-analysis, OP was proved to have the advantage of a shorter operative time and more resected weight compared with laser surgery, which was inconsistent with the current result [33]. All studies included in the previous meta-analysis were before 2008, and the current meta-analysis includes 2016 to 2019. The probable explanations for changes in operation duration include the following: First, with the optimization of the learning curve of transurethral laser prostatectomy, the accumulation of operations makes urologists more efficient and more skilled. Second, surgical duration is further reduced with the development of tissue morcellator and the increase

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Table 5. Sensitivity analysis of 3 high-quality RCTs comparing transurethral laser with OP

Outcome of interest	Study	No. of patients (laser/OP)	OR/WMD (95 % CI)	p-value	Study heterogeneity χ^2	df	I^2 (%)	p-value	Favors
Perioperative outcomes									
Operative time (min)	[24,25,28]	166/159	28.85 (14.01 to 43.69)	0.0001*	26.99	2	93	<0.00001	OP
Hemoglobin decrease (g/dL)	[24,25,28]	166/159	-0.97 (-1.31 to -0.64)	<0.001*	0.13	2	0	0.94	Laser
Resected prostate weight (g)	[24,28]	101/99	-14.83 (-40.13 to 10.47)	0.25	6.44	1	84	0.01	None
Catheterization (d)	[24,25,28]	166/159	-4.44 (-7.11 to -1.76)	0.001*	359.11	2	99	<0.00001	Laser
Hospital stay (d)	[24,25,28]	166/159	-4.64 (-7.19 to -2.08)	0.0004*	158.09	2	99	<0.00001	Laser
Effectiveness-related outcomes									
IPSS									
1 month	[24,25,28]	163/152	0.50 (-0.94 to 1.93)	0.50	8.72	2	77	0.01	None
3 months	[24,25,28]	160/149	0.28 (-0.38 to 0.94)	0.40	2.58	2	23	0.28	None
6 months	[24,25]	119/110	-0.22 (-1.11 to 0.67)	0.62	0.19	1	0	0.66	None
12 months	[24,25,28]	154/140	0.29 (-0.34 to 0.91)	0.37	0.03	2	0	0.99	None
Qmax (mL/s)									
1 month	[24,25,28]	163/152	0.45 (-0.56 to 1.45)	0.38	1.24	2	0	0.54	None
3 months	[24,25,28]	160/149	0.16 (-1.79 to 2.10)	0.88	4.06	2	51	0.13	None
6 months	[24,25]	119/110	1.49 (0.40 to 2.57)	0.007*	1.76	1	43	0.18	OP
12 months	[24,25,28]	154/140	-0.44 (-2.58 to 1.69)	0.69	5.17	2	61	0.08	None
QoL (3 mo)	[25,28]	106/99	0.05 (-0.63 to 0.73)	0.88	13.72	1	93	0.0002	None
PVR (3 mo, mL)	[24,25]	119/110	3.15 (-1.74 to 8.04)	0.21	0.73	1	0	0.39	None
Complications									
Stress incontinence	[25,28]	106/99	1.58[a] (0.20 to 12.20)	0.66	0.25	1	0	0.62	None
Acute urinary retention	[25,28]	106/99	1.06[a] (0.26 to 4.22)	0.94	2.03	1	51	0.15	None
Blood transfusion	[24,25,28]	166/159	0.10[a] (0.03 to 0.35)	0.0003*	1.49	2	0	0.47	Laser

RCT, randomized controlled trial; OP, open prostatectomy; OR, odds ratio; WMD, weighted mean difference; CI, confidence interval; IPSS, International Prostate Symptom Score; Qmax, maximum flow rate; QoL, quality of life score; PVR, postvoid residual volume.
[a]Values are presented as OR.
*Statistically significant results (p<0.05).

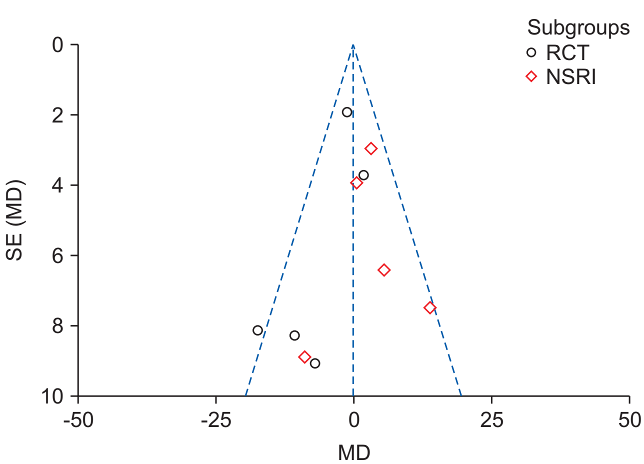

Fig. 2. Funnel plot for prostate volume. Funnel plot with pseudo 95% confidence limits. SE, standard error; MD, mean difference; RCT, randomized controlled trial; NRSI, non-randomised studies of the effects of intervention.

of laser power. In addition, improved surgical techniques have a very good effect on permitting less operation time, such as the diversity of surgical methods. Transurethral laser surgery is no longer a single resection, enucleation or vaporization, but a fusion of two or three. Therefore, with the faster development and further promotion of laser technology, its efficiency is progressively improving, even more than open surgery. As for resected tissue weight, endoscopic laser is able to remove the adenoma close to the surgical capsule without depending on the volume of the prostate, similarly to what the index finger does during an OP procedure [15]. Furthermore, the wide application of tissue morcellator protects resected specimens and reduces the loss of specimen volume in transurethral laser prostatectomy. Although the pooled data revealed that the resected tissue weights between the two groups were not significantly different, 1 trial reported that transurethral laser yielded much more specimen weights compared with OP [23]. The subgroup analysis was not carried out due to limited sample size.

The surgical goal of BPH should be safe removal of adenoma to relieve BOO, while improving LUTS significantly. No statistically significant difference was observed in related parameters of Qmax, PVR, QoL, and IPSS at the dif-

Table 6. The Newcastle–Ottawa scale scores for quality assessment of non-RCTs

Study	Selection				Comparability	Outcome			Total score
	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Outcome of interest was not present at start of study	Comparability based on the design or analysis	Assessment of outcome	Follow-up long enough for outcomes to occur	Adequacy of follow-up of cohorts	
Moody and Lingeman [23]	1	1	1	1	2	1	1	0	8
Elshal et al. [22]	1	1	1	1	2	1	1	1	9
Lanchon et al. [21]	1	1	1	1	2	1	1	1	9
Misraï et al. [8]	1	1	1	1	2	1	1	1	9
Rosenhammer et al. [20]	1	1	1	1	2	1	0	0	7
Enikeev et al. [19]	1	1	1	1	2	1	1	0	8
Nestler et al. [2]	1	1	1	1	2	1	1	0	8

RCT, randomized controlled trial.

ferent follow-ups. Although LUTS significantly lessened for both groups in the early follow-up of the meta-analysis, the effect can be sustained depends on more long-term follow-ups. However, similar studies about large prostates will be less, as OP is increasingly being replaced by laparoscopic or robotic prostatectomy.

The overall complication rates were not significantly different between transurethral laser surgery and OP, except for transfusion rate of the meta-analysis. Laser had excellent hemostatic property, which makes the transfusion rate of laser surgery less than that of OP. Unfortunately, the number of the enrolled studies comparing complications was small, and some studies just provided overall complication rate without furnishing the specific adverse events, which may cause some bias, but our meta-analysis indicates that transurethral laser prostatectomy is at least as safe as OP. The smooth urination continence after the surgery is the key for surgical treatment of large-sized BPH. Compared with OP, transurethral laser prostatectomy for large prostates had similar incidence of AUR, stress incontinence, and transitory urge incontinence. In previously published studies, transurethral laser prostatectomy and OP were similar in terms of urination continence [11,13-16]. Our analysis also confirmed these results.

There are some certain constraints in this study. First of all, the sample size of most enrolled studies was not large enough. Although one large-scale study was included, this study was not an RCT research, which has selection bias [8]. Next, some papers did not provide micturition parameters (Qmax, PVR, QoL, and IPSS), which is the key to the surgery, although some papers reported these parameters. Last but not least, most enrolled studies in the meta-analysis reported an insufficient follow-up period, and follow-up period of most studies is not more than two years.

CONCLUSIONS

Both OP and transurethral laser prostatectomy are effective and safe treatments for large prostate adenomas. With these advantages of less blood loss and transfusion, and shorter catheterization time and hospital stay, laser may be a better choice for large BPH who need surgical treatment.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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AUTHORS' CONTRIBUTIONS

Research conception and design: Da-hong Zhang. Data acquisition: Hai-bin Wei and Bing-yi Guo. Statistical analysis: Xuan-han Hu. Data analysis and interpretation: Yao-fen Tu and Wei Zheng. Drafting of the manuscript: Hai-bin Wei and Wei Zheng. Critical revision of the manuscript: Jian Zhuo. Obtaining funding: Hai-bin Wei and Jian Zhuo. Administrative, technical, or material support: Jian Zhuo. Supervision: Jian Zhuo. Approval of the final manuscript: Da-hong Zhang and Jian Zhuo.

REFERENCES

1. Berry SJ, Coffey DS, Walsh PC, Ewing LL. The development of human benign prostatic hyperplasia with age. J Urol 1984;132:474-9.
2. Nestler S, Bach T, Herrmann T, Jutzi S, Roos FC, Hampel C, et al. Surgical treatment of large volume prostates: a matched pair analysis comparing the open, endoscopic (ThuVEP) and robotic approach. World J Urol 2019;37:1927-31.
3. Gratzke C, Bachmann A, Descazeaud A, Drake MJ, Madersbacher S, Mamoulakis C, et al. EAU guidelines on the assessment of non-neurogenic male lower urinary tract symptoms including benign prostatic obstruction. Eur Urol 2015;67:1099-109.
4. Elkoushy MA, Elhilali MM. Management of benign prostatic hyperplasia larger than 100 ml: simple open enucleation versus transurethral laser prostatectomy. Curr Urol Rep 2016;17:44.
5. Wang MQ, Guo LP, Zhang GD, Yuan K, Li K, Duan F, et al. Prostatic arterial embolization for the treatment of lower urinary tract symptoms due to large (>80 mL) benign prostatic hyperplasia: results of midterm follow-up from Chinese population. BMC Urol 2015;15:33.
6. Gilling PJ, Cass CB, Cresswell MD, Fraundorfer MR. Holmium laser resection of the prostate: preliminary results of a new method for the treatment of benign prostatic hyperplasia. Urology 1996;47:48-51.
7. Valdivieso R, Hueber PA, Meskawi M, Belleville E, Ajib K, Bruyere F, et al. Multicentre international experience of 532-nm laser photoselective vaporization with GreenLight XPS in men with very large prostates. BJU Int 2018;122:873-8.
8. Misraï V, Pasquie M, Bordier B, Elman B, Lhez JM, Guillotreau J, et al. Comparison between open simple prostatectomy and green laser enucleation of the prostate for treating large benign prostatic hyperplasia: a single-centre experience. World J Urol 2018;36:793-9.
9. Umari P, Fossati N, Gandaglia G, Pokorny M, De Groote R, Geurts N, et al. Robotic assisted simple prostatectomy versus holmium laser enucleation of the prostate for lower urinary tract symptoms in patients with large volume prostate: a comparative analysis from a high volume center. J Urol 2017;197:1108-14.
10. Liu D, Fan L, Liu C, Liu XJ, Zhu DS, Mu JG, et al. [Transurethral diode laser enucleation versus transurethral electrovaporization resection of the prostate for benign prostatic hyperplasia with different prostate volumes]. Zhonghua Nan Ke Xue 2017;23:217-22. Chinese.
11. Zhang X, Shen P, He Q, Yin X, Chen Z, Gui H, et al. Different lasers in the treatment of benign prostatic hyperplasia: a network meta-analysis. Sci Rep 2016;6:23503.
12. Lin Y, Wu X, Xu A, Ren R, Zhou X, Wen Y, et al. Transurethral enucleation of the prostate versus transvesical open prostatectomy for large benign prostatic hyperplasia: a systematic review and meta-analysis of randomized controlled trials. World J Urol 2016;34:1207-19.
13. Jones P, Alzweri L, Rai BP, Somani BK, Bates C, Aboumarzouk OM. Holmium laser enucleation versus simple prostatectomy for treating large prostates: results of a systematic review and meta-analysis. Arab J Urol 2016;14:50-8.
14. Lucca I, Shariat SF, Hofbauer SL, Klatte T. Outcomes of minimally invasive simple prostatectomy for benign prostatic hyperplasia: a systematic review and meta-analysis. World J Urol 2015;33:563-70.
15. Li M, Qiu J, Hou Q, Wang D, Huang W, Hu C, et al. Endoscopic enucleation versus open prostatectomy for treating large benign prostatic hyperplasia: a meta-analysis of randomized controlled trials. PLoS One 2015;10:e0121265.
16. Zhu Y, Zhuo J, Xu D, Xia S, Herrmann TR. Thulium laser versus standard transurethral resection of the prostate for benign prostatic obstruction: a systematic review and meta-analysis. World J Urol 2015;33:509-15.
17. Luo D, Wan X, Liu J, Tong T. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. Stat Methods Med Res 2018;27:1785-805.
18. Wan X, Wang W, Liu J, Tong T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Med Res Methodol 2014;14:135.

19. Enikeev D, Okhunov Z, Rapoport L, Taratkin M, Enikeev M, Snurnitsyna O, et al. Novel thulium fiber laser for enucleation of prostate: a retrospective comparison with open simple prostatectomy. J Endourol 2019;33:16-21.
20. Rosenhammer B, Lausenmeyer EM, Mayr R, Burger M, Eichelberg C. Holmium laser enucleation of the prostate provides similar incidental prostate cancer detection rates as open prostatectomy: a matched pair analysis. Urol Int 2018;101:382-6.
21. Lanchon C, Fiard G, Long JA, Arnoux V, Carnicelli D, Franquet Q, et al. Open prostatectomy versus 180-W XPS GreenLight laser vaporization: long-term functional outcome for prostatic adenomas>80 g. Prog Urol 2018;28:180-7.
22. Elshal AM, Mekkawy R, Laymon M, Barakat TS, Elsaadany MM, El-Assmy A, et al. Holmium laser enucleation of the prostate for treatment for large-sized benign prostate hyperplasia; is it a realistic endourologic alternative in developing country? World J Urol 2016;34:399-405.
23. Moody JA, Lingeman JE. Holmium laser enucleation for prostate adenoma greater than 100 gm.: comparison to open prostatectomy. J Urol 2001;165:459-62.
24. 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.
25. Alivizatos G, Skolarikos A, Chalikopoulos D, Papachristou C, Sopilidis O, Dellis A, et al. Transurethral photoselective vaporization versus transvesical open enucleation for prostatic adenomas >80ml: 12-mo results of a randomized prospective study. Eur Urol 2008;54:427-37.
26. Zhang Y, Du CJ, Xu G, Chen JM, Jing X. [Transurethral holmium laser enucleation for prostate adenoma greater than 100 g]. Zhonghua Nan Ke Xue 2007;13:1091-3. Chinese.
27. Salonia A, Suardi N, Naspro R, Mazzoccoli B, Zanni G, Gallina A, et al. Holmium laser enucleation versus open prostatectomy for benign prostatic hyperplasia: an inpatient cost analysis. Urology 2006;68:302-6.
28. Naspro R, Suardi N, Salonia A, Scattoni V, Guazzoni G, Colombo R, et al. Holmium laser enucleation of the prostate versus open prostatectomy for prostates >70 g: 24-month follow-up. Eur Urol 2006;50:563-8.
29. Raimbault M, Watt S, Bourgoin H, Brichart N, Bruyère F. [Comparative analysis of photoselective vaporization of the prostate with the Greenlight laser and open prostatectomy for high volume prostate hypertrophy]. Prog Urol 2014;24:470-6. French.
30. 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.
31. Kuntz RM, Lehrich K, Ahyai S. Transurethral holmium laser enucleation of the prostate compared with transvesical open prostatectomy: 18-month follow-up of a randomized trial. J Endourol 2004;18:189-91.
32. Kuntz RM, Lehrich K. Transurethral holmium laser enucleation versus transvesical open enucleation for prostate adenoma greater than 100 gm.:: a randomized prospective trial of 120 patients. J Urol 2002;168(4 Pt 1):1465-9.
33. Haibin W, Lin Q, Junxiu W, Heng W, Qi Z, Yanpeng W, et al. Transurethral laser versus open simple prostatectomy for large volume prostates: a systematic review and meta-analysis of randomized controlled trials. Lasers Med Sci 2021;36:1191-200.
34. Ferretti M, Phillips J. Prostatectomy for benign prostate disease: open, laparoscopic and robotic techniques. Can J Urol 2015;22 Suppl 1:60-6.
35. Varkarakis I, Kyriakakis Z, Delis A, Protogerou V, Deliveliotis C. Long-term results of open transvesical prostatectomy from a contemporary series of patients. Urology 2004;64:306-10.
36. Tamalunas A, Westhofen T, Schott M, Keller P, Atzler M, Stief CG, et al. Holmium laser enucleation of the prostate: a truly size-independent method? Low Urin Tract Symptoms 2022;14:17-2.

 https://doi.org/10.4111/icu.20210281