

RESEARCH ARTICLE

Efficacy and Safety of Laser Surgery and Transurethral Resection of the Prostate for Treating Benign Prostate Hyperplasia: a Network Meta-analysis

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Abstract

Background: Traditional meta-analyses or systematic reviews of randomized controlled trials (RCTs) have been used to compare laser surgeries and transurethral resection of the prostate (TURP) for benign prostate hyperplasia (BPH), but they cannot provide a hierarchy regarding efficacy and safety of treatment. **Objective:** We therefore performed a network meta-analysis (NMA) to compare and create hierarchies for efficacy and safety of TURP and laser surgeries for BPH. **Materials and Methods:** We searched for reports of RCTs published up to April 25, 2015. After methodological quality assessment and data extraction, we performed an NMA to compare TURP and laser surgeries for BPH. **Results:** We ranked the treatments of TURP and laser surgeries for BPH. For IPSS at 6 months, holmium laser resection of the prostate (HoLRP) ranked the first-best and at 12 months, holmium laser enucleation of the prostate (HoLEP). For Qmax at 6 and 12 months, HoLEP ranked the first-best; for operative time it was TURP; for catheter removal time, diode laser enucleation of the prostate (DiLEP) ranked the first-best. **Conclusions:** Although TURP is considered the gold standard for treating BPH, it is not better in terms of efficacy and safety compared with the laser surgery. Our NMA created hierarchies for the 9 types of surgery in terms of efficacy and safety, which should help clinicians choose the best approach for the individual patient.

Keywords: TURP - BPH - laser surgery - meta-analysis

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Introduction

Benign prostatic hyperplasia (BPH), one of the most common and serious diseases affecting men, is considered the main reason for urinary tract symptoms. The disease affects about 50% men by the age of 60 years and 90% by the age of 85 (Roberts et al., 1998; Roehrborn et al., 2000). Various surgical treatments for treatment include transurethral resection of the prostate (TURP), open prostatectomy, holmium laser enucleation of the prostate (HoLEP), and photoselective vaporization of prostate (PVP). Although TURP is considered the gold standard treatment for BPH, the procedure has some limitations. Several studies (Oesterling, 1995; Shingleton et al., 1999; Lertakyamanee et al., 2002; Mebust et al., 2002; Committee, 2003; Rassweiler et al., 2006) reported complications following TURP, including transfusions, infections, urethral stricture, sexual dysfunction, urinary incontinence, urinary retention, clot retention and TUR syndrome.

Other treatments, such as laser prostatectomy, including photoselective vaporization of prostate (PVP); thulium laser enucleation of the prostate (ThuLEP) and

thulium laser resection of the prostate (TmLRP); HoLEP, holmium laser resection of the prostate (HoLRP) and holmium laser ablation of the prostate (HoLAP); and diode laser enucleation of the prostate (DiLEP) and diode laser vaporisation of the prostate (DiLVP), have emerged as treatment. As compared with TURP, HoLEP has less blood transfusion rate, shorter catheterization duration time and hospital stay (Li et al., 2014), and PVP is less likely to have postoperative complications of blood transfusion and clot retention (Thangasamy et al., 2012).

Traditional meta-analyses or systematic reviews based on randomized controlled trials (RCTs) of laser surgeries and TURP for BPH cannot provide a hierarchy of the efficacy and safety of treatment. We performed a network meta-analysis (NMA) to evaluate and create hierarchies for the efficacy and safety of laser surgery and TURP for BPH.

Materials and Methods

Studies were eligible for inclusion

We included reports of RCTs that involved TURP and PVP, HoLEP, ThuLEP, TmLRP, HoLRP, HoLAP,

DiLEP, or DiLVP as the intervention and control arms, respectively, and reported the efficacy, safety or perioperative outcomes international prostate symptom score (IPSS), maximum flow rate (Qmax) (ml/s), quality of life (QoL), postvoid residual volume (PVR) (ml), blood transfusion, urethral stricture, TUR syndrome, bladder neck contracture, reoperation, urinary tract infection (UTI), acute urinary retention (AUR), operating time (min), catheterization time (day), or hospital stay (day).

Search strategy

We searched MEDLINE via PubMed for reports of RCTs published in English up to April 15, 2015. The search algorithm was (“Prostatic Hyperplasia/surgery”[Mesh] AND (“lasers”[MeSH Terms] OR “lasers”[All Fields] OR “laser”[All Fields])) OR (“Prostatic Hyperplasia/surgery”[Mesh] AND “Transurethral Resection of Prostate”[Mesh]) AND Clinical Trial[ptyp]. We also searched ClinicalTrials.gov and reference lists of previous systematic reviews or meta-analyses (Ahyiaia et al., 2010; Mamoulakis et al., 2010; Thangasamy et al., 2012). We included published and unpublished reports of RCTs and excluded many from China to avoid systematic bias because many of these studies do not use an appropriate randomization procedure (13). Five reviewers (LW, QY, YL, ZZ and YH) independently assessed the titles and abstracts of the articles to determine inclusion.

Any discrepancies were resolved by consulting a sixth researcher (KL).

Data extraction and quality assessment

The data were extracted independently by the 5 reviewers; disagreements were resolved by discussion. We used the Cochrane Collaboration tool 17 to assess the quality of reports, including sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting of outcomes and other possible sources of bias. Two reviewers (LW, QY) independently performed the quality assessment. For every comparison of TURP and/or laser surgical treatments (PVP, HoLEP, ThuLEP, TmLRP, HoLRP, HoLAP, DiLEP, DiLVP), the standardized mean difference Hedges’s adjusted g (SMD) was calculated as the relative effect size for continuous outcomes and the odds ratio (OR) for binary outcomes.

Outcome measures

Primary outcomes were Qmax and IPSS at 6 and 12 months. Secondary outcomes were operative time, hospital time, catheter removal time and complications such as urethral stricture.

Statistical analysis

Bayesian-framework, network/multi-treatment meta-analysis integrates direct and indirect effects for all relative

Table 1. Baseline characteristics of the studies included

Study	Surgery types	No. of studies	Age(year)	IPSS		Qmax	Laser types
				T1/T2	T1/T2		
Ehab A.Elzayat et al.	HoLAP/PVP	57/52	72.7/71.6	20/18.4	6.7/6.4	6.7/6.4	Ho:YAG/Green Light
Ahmed M.Elshal et al.	HoLEP/PVP	50/53	71/74.1	22.4/23	7.5/8	7.5/8	Ho:YAG/Green Light
Hazem Elmansy et al.	HoLEP/PVP	43/37	71.5/73.2	22.4/21.8	8.1/8.9	8.1/8.9	Ho:YAG/Green Light
Fengbo Zhang et al.	ThuLEP/HoLEP	71/62	76.2/73.4	24.6/22.8	6.8/7.3	6.8/7.3	Tm:YAG/Ho:YAG
Po Hui Chiang et al.	PVP/DiLVP	84/55	69.1/72.7	21.6/20.1	4.3/5.5	4.3/5.5	Green Light/Diode Laser
Stephen S.Yang et al.	DiLEP/TURP	74/52	70.7/71	na	na/na	na/na	Diode Laser/-
Mohammad Reza Razzaghi et al.	DiLVP/TURP	50/52	68.5/68.2	23.6/24.6	6.8/6.3	6.8/6.3	Diode Laser/-
A.H.H.TAN et al.	TURP/HoLEP	30/31	70.3/71.7	23.7/26	8.3/8.4	8.3/8.4	-/Ho:YAG
FRANCESCO MONTORSI et al.	TURP/HoLEP	48/52	64.5/65.1	21.9/21.6	7.8/8.2	7.8/8.2	-/Ho:YAG
ANDRE WESTENBERG et al.	TURP/HoLEP	59/61	66.8/66.9	23/21.9	9.1/8.9	9.1/8.9	-/Ho:YAG
RAINER M.KUNTZ et al.	TURP/HoLEP	100/100	68.7/68	22.1/21.4	5.9/4.9	5.9/4.9	-/Ho:YAG
R.M.Mavuduru et al.	TURP/HoLEP	15/15	66.46/69.86	21.4/22.53	6.9/5.79	6.9/5.79	-/Ho:YAG
Nao Sun et al.	TURP/HoLEP	82/82	71.91/72.16	24.55/24.4	5.69/5.28	5.69/5.28	-/Ho:YAG
PETER J.GILLING et al.	TURP/HoLRP	59/61	66.8/66.9	23/21.9	9.1/8.9	9.1/8.9	-/Ho:YAG
Alexander Bachmann et al.	TURP/PVP	142/139	65.4/65.9	21.7/21.2	9.9/9.5	9.9/9.5	-/Green Light
Boxin Xue et al.	TURP/PVP	100/100	71/72.1	23.2/23	8.2/8	8.2/8	-/Green Light
Carlos Capitan et al.	TURP/PVP	50/50	67.7/69.8	23.52/23.75	8.68/8.03	8.68/8.03	-/Green Light
Bogdan Geavlete et al.	TURP/PVP	80/75	na/na	24.4/24.2	6.3/6.2	6.3/6.2	-/Green Light
Abdulla Al et al.	TURP/PVP	60/60	67.1/66.3	27.9/27.2	6.4/6.9	6.4/6.9	-/Green Light
David M.Bouchier et al.	TURP/PVP	59/60	66.36/65.06	25.41/25.28	5.08/4.74	5.08/4.74	-/Green Light
Kaya Horasanll et al.	TURP/PVP	37/39	68.3/69.2	20.2/18.9	9.2/8.6	9.2/8.6	-/Green Light
Volkan Tugcu et al.	TURP/PVP	98/112	66.3/67.5	17.7/17.7	7.2/6.9	7.2/6.9	-/Green Light
DAVID M. BOUCHIER et al.	TURP/PVP	38/38	66.23/65.23	na/na	na/na	na/na	-/Green Light
W. BRUCE SHINGLETON et al.	TURP/PVP	50/50	67.4/68.2	21/22	6.9/8	6.9/8	-/Green Light
Shu-Jie Xia et al.	TURP/TmLRP	48/52	69.3/68.9	20.8/21.9	8.3/8	8.3/8	-/Tm:YAG
Di Cui et al.	TURP/TmLRP	49/47	70.4/67.8	20.2/21.1	8.4/8.62	8.4/8.62	-/Tm:YAG
Hao Yan et al.	TURP/TmLRP	40/40	74.5/72.5	22.6/21.7	7.8/7.5	7.8/7.5	-/Tm:YAG

Abbreviations: IPSS, international prostate symptom score; Qmax, maximum urinary flow rate; TURP, transurethral resection of the prostate; PVP, photoselective vaporisation of the prostate; HoLEP, holmium laser enucleation of the prostate; HoLAP, holmium laser ablation of the prostate; HoLRP, holmium laser resection of the prostate; TmLRP, thulium laser resection of the prostate; ThuLEP, thulium laser enucleation of the prostate; DiLEP, diode laser enucleation of the prostate; DiLVP, diode laser vaporisation of the prostate; na, not available; -, no parameter; T1, the first group; T2, the second group

treatments and provides estimates with maximum power (HIGGINS and Whitehead, 1996; Lu and Ades, 2004; Jansen et al., 2008; Salanti et al., 2008). Our NMA with

a Bayesian-framework to compare TURP with other laser treatments for BPH allowed for the integration of direct and indirect comparisons. We used forest plots to investigate statistical heterogeneity by the I^2 statistic (Higgins and JPT, 2008) with $I^2 < 25\%$ considered low heterogeneity and $> 50\%$ high heterogeneity (Schmid et al., 2013). We calculated probability of events with ORs and 95% confidence intervals (95% CIs) for binary outcomes and SMD and 95% CIs for continuous outcomes. Inconsistency was defined as the difference between direct and indirect evidence with 95% CI excluding 0; we checked for inconsistency with a triangular loop graph (Higgins et al., 2012). We calculated the probability of each surgical procedure being the best treatment and ranked treatments (Lu and Ades, 2004; Ades et al., 2006). Analyses involved use of Review Manager 5.3 (quality assessment of RCTs), STATA 12.0 (pairwise meta-analysis and I^2 calculations), R 3.0.3 (estimation of inconsistency between direct and indirect evidence, ranking treatments), and WinBUGS 1.4.3 (NMA models) (Salanti et al., 2011).

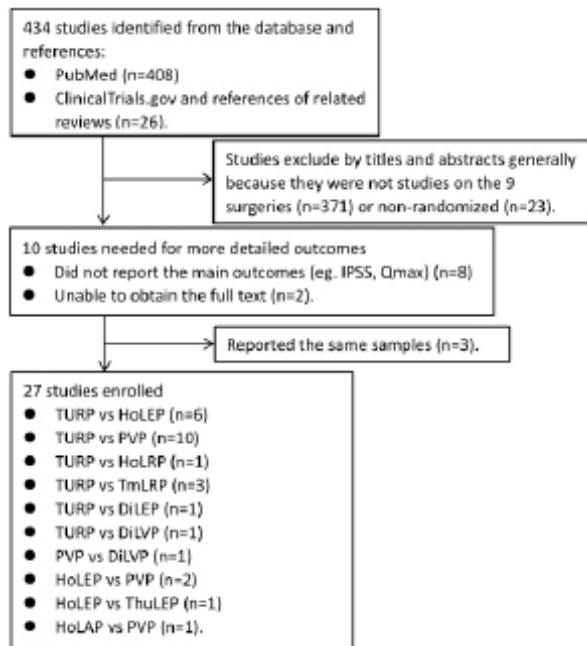


Figure 1. Flow Diagram of Screening Randomized Controlled Trials

Results

After screening, 27 reports of RCTs (Gilling et al., 1999; Shingleton et al., 1999; Tan et al., 2003; Kuntz et al., 2004; Montorsi et al., 2004; Westenberg et al., 2004; Bouchier-Hayes et al., 2006; Horasanli et al.,

Table 2. Heterogeneity between Studies

Variables	Comparisons	No. of studies	Heterogeneity
OT	TURP VS. PVP	5	$\chi^2=0.15, P=0.004, I^2=74.3\%$
	TURP VS. HoLEP	4	$\chi^2=9.60, P=0.022, I^2=68.7\%$
	PVP VS. HoLEP	2	$\chi^2=1.72, P=0.190, I^2=41.9\%$
	TURP VS. TmLRP	2	$\chi^2=3.53, P=0.060, I^2=71.6\%$
CT	TURP VS. PVP	7	$\chi^2=9.34, P=0.155, I^2=35.8\%$
	TURP VS. HoLEP	5	$\chi^2=17.85, P=0.001, I^2=77.6\%$
	TURP VS. HoLRP	2	$\chi^2=0.00, P=0.975, I^2=0.0\%$
	PVP VS. HoLEP	2	$\chi^2=0.42, P=0.516, I^2=0.0\%$
HT	TURP VS. PVP	7	$\chi^2=29.72, P=0.000, I^2=79.8\%$
	TURP VS. HoLEP	4	$\chi^2=10.77, P=0.013, I^2=72.1\%$
US	TURP VS. PVP	7	$\chi^2=6.06, P=0.416, I^2=1.0\%$
	TURP VS. HoLEP	5	$\chi^2=2.91, P=0.573, I^2=0.0\%$
	TURP VS. TmLRP	3	$\chi^2=0.51, P=0.776, I^2=0.0\%$
Qmax at 6 months	TURP VS. PVP	5	$\chi^2=14.70, P=0.005, I^2=72.8\%$
	TURP VS. HoLEP	4	$\chi^2=14.00, P=0.003, I^2=78.6\%$
Qmax at 12 months	TURP VS. PVP	3	$\chi^2=1.03, P=0.599, I^2=0.0\%$
	TURP VS. HoLEP	5	$\chi^2=17.62, P=0.001, I^2=77.3\%$
	TURP VS. TmLRP	2	$\chi^2=0.00, P=0.994, I^2=0.0\%$
IPSS at 6 months	TURP VS. PVP	4	$\chi^2=10.35, P=0.016, I^2=71.0\%$
	TURP VS. HoLEP	4	$\chi^2=13.74, P=0.003, I^2=78.2\%$
IPSS at 12 months	TURP VS. PVP	2	$\chi^2=0.37, P=0.541, I^2=0.0\%$
	TURP VS. HoLEP	5	$\chi^2=14.68, P=0.005, I^2=72.8\%$
	TURP VS. TmLRP	2	$\chi^2=0.00, P=0.944, I^2=0.0\%$

Abbreviations: CT, catheter removal time; HT, hospital time; IPSS, international prostate symptom score; OT, operative time; Qmax, maximum urinary flow rate; TURP, transurethral resection of the prostate; PVP, photoselective vaporisation of the prostate; HoLEP, holmium laser enucleation of the prostate; TmLRP, thulium laser resection of the prostate; US, urethral stricture

Table 3. Efficacy (IPSS and Qmax at 6 months) of All the Surgeries (SMD with 95% CI)

TURP	-1.27 (-3.52,0.78)	-0.33 (-2.48,1.77)	-0.17 (-4.94,4.36)	1.29 (-3.41,6.53)	-3.19 (-8.49,2.43)	0.01 (-3.35,3.61)
1.22 (-1.24,4.13)	PVP	0.94 (-1.90,3.42)	1.1 (-3.46,6.40)	2.56 (-2.62,7.77)	-1.93 (-7.22,3.74)	1.28 (-2.19,5.18)
-2.4 (-5.01,0.58)	-3.61 (-7.06,-0.12)	HoLEP	0.16 (-4.69,4.80)	1.62 (-3.50,7.24)	-2.87 (-8.73,2.53)	0.34 (-3.63,4.29)
-1.22 (-7.82,5.57)	-2.43 (-9.61,4.78)	1.18 (3.65,8.34)	HoLRP	1.46 (-5.06,8.21)	-3.03 (-10.06,4.20)	0.18 (-5.44,5.69)
-1.65 (-8.06,4.52)	-2.86 (-9.76,3.64)	0.75 (-5.99,7.47)	-0.43 (-9.55,8.34)	TmLRP	-4.49 (-11.87,2.47)	-1.28 (-7.22,4.64)
3.34 (-3.03,10.47)	2.13 (-4.08,8.66)	5.74 (-1.72,12.99)	4.56 (-4.45,14.80)	4.99 (-4.27,14.45)	HoLAP	3.21 (-2.96,9.47)
2.23 (-2.19,6.72)	1.02 (-3.53,5.30)	4.63 (-0.48,9.79)	3.45 (-4.55,11.14)	3.88 (-3.81,11.90)	-1.11 (-9.06,6.68)	DiLVP

Table 4. Efficacy (IPSS and Qmax at 12 months) of All the Surgeries (SMD with 95% CI)

TURP	0.2436 (-1.21,1.91)	1.09 (-0.07,2.23)	0.44 (-1.81,2.59)	0.07 (-2.99,3.28)	2.23 (-1.71,5.78)	-0.54 (-2.76,1.75)
0.62 (-0.81,2.67)	PVP	0.85 (-0.99,2.45)	0.20 (-2.58,2.75)	-0.18 (-3.84,3.27)	1.99 (-1.58,5.06)	-0.79 (-2.86,1.09)
-2.4721 (-3.84,-1.05)	-3.09 (-5.46,-1.23)	HoLEP	-0.65 (-3.31,1.69)	-1.02 (-4.41,2.41)	1.14 (-2.74,4.86)	-1.63 (-4.02,0.79)
0.09 (-2.27,2.30)	-0.54 (-3.60,2.16)	2.56 (-0.18,5.17)	HoLRP	-0.38 (-4.27,3.49)	1.79 (-2.70,5.85)	-0.99 (-3.81,2.02)
-4.88 (-9.16,-0.33)	-5.5 (-10.47,-0.80)	-2.4 (-6.85,2.30)	-4.96 (-10.14,0.48)	TmLRP	2.16 (-2.97,6.91)	-0.61 (-4.35,3.19)
1.8 (-2.67,6.44)	1.18 (-3.06,5.37)	4.27 (-0.30,9.14)	1.72 (-3.37,7.14)	6.68 (0.85,13.12)	HoLAP	-2.77 (-14.97,44.97)
2.73 (0.49,4.98)	2.11 (-0.83,4.38)	5.2 (2.44,7.64)	2.64 (-0.52,5.92)	7.6 (2.42,12.70)	0.93 (-3.94,5.71)	DiLVP

Table 5. Safety (Urethral stricture(RR with 95% CI)) and Efficacy (Length of hospital stay (SMD with 95% CI)) of All the Surgeries

TURP	0.48 (0.12,1.13)	0.93 (0.21,2.61)	0.51 (0.02,2.12)	3.77 (0.07,10.09)	0.39 (0.00,2.43)	0.87 (0.02,4.56)
1.77 (1.13,2.41)	PVP	2.82 (0.36,11.34)	1.52 (0.04,8.55)	21.84 (0.19,36.59)	0.95 (0.01,4.89)	2.02 (0.07,10.14)
1.26 (0.49,1.97)	-0.51 (-1.42,0.38)	HoLEP	0.81 (0.02,3.93)	63.68 (0.08,20.77)	0.87 (0.00,3.92)	1.48 (0.02,7.32)
1.91 (0.28,3.45)	0.14 (-1.69,1.87)	0.65 (0.10,2.41)	TmLRP	40.07 (0.13,99.52)	3.74 (0.00,19.71)	11.99 (0.03,40.31)
0.87 (-0.63,2.44)	-0.9 (-2.60,0.82)	-0.39 (-2.06,1.40)	-1.04 (-3.17,1.07)	HoLRP	0.85 (0.00,4.00)	2.06 (0.01,11.78)
1.84 (0.19,3.43)	0.07 (-1.38,1.66)	0.58 (-1.13,2.39)	-0.07 (-2.45,2.25)	0.97 (-1.27,3.30)	HoLAP	18.31 (0.07,32.10)
0.68 (-0.89,2.28)	-1.09 (-2.81,0.66)	-0.58 (-2.38,1.31)	-1.23 (-3.51,1.16)	-0.19 (-2.55,2.01)	-1.16 (-3.53,1.34)	DiLEP
1.45 (-0.19,2.92)	-0.33 (-2.07,1.31)	0.18 (-1.54,1.80)	-0.47 (-2.56,1.80)	0.57 (-1.65,2.74)	-0.39 (-2.45,1.80)	0.76 (-1.42,2.97)
						DiLVP

2008; Tugcu et al., 2008; Xia et al., 2008; Elzayat and Al, 2009; Mavuduru et al., 2009; Al-Ansari et al., 2010; Bouchier-Hayes et al., 2010; Geavlete et al., 2010; PhD et al., 2010; Capitán et al., 2011; Elmansy et al., 2012; Yang et al., 2012; Zhang et al., 2012; Cui et al., 2013; Xue et al., 2013; Yan et al., 2013; Bachmann et al., 2014; Elshal et al., 2014; Razzaghi et al., 2014; Sun et al., 2014) were

included (Figure 1) in our multiple-treatments NMA of the 9 surgical treatments (Figure 2). Quality assessment is in Figure 3. Most RCTs were not blinded, and some reports did not include details about concealment. All trials were two-arm studies.

A total of 14 articles of RCTs (1,664 patients) reported the IPSS at 6 months and 14 (1,524 patients) at 12 months

Table 6. Efficacy (operative time and catheter remove time) of All the Surgeries (SUMC with 95% CI)

TURP	-11.49 (-15.77 to -7.24)	-14.34 (-19.84 to -8.55)	-25.07 (-37.51 to -13.10)	-0.99 (-9.53 to 7.24)	-25.73 (-40.03 to -11.65)	-4.91 (-20.55 to 10.16)	-5.84 (-17.15 to 7.03)
1.30 (0.91 to 1.67)	PVP	-2.85 (-9.71 to 3.85)	-13.57 (-26.23 to -0.66)	10.51 (0.46 to 20.15)	-14.24 (-27.68 to -0.67)	6.58 (-9.12 to 23.14)	5.65 (-6.53 to 19.33)
1.18 (0.75 to 1.63)	-0.12 (-0.62 to 0.44)	HoLEP	-10.72 (-22.77 to 0.42)	13.36 (2.78 to 23.22)	-11.39 (-26.09 to 3.22)	9.43 (-7.46 to 25.19)	8.50 (-4.63 to 22.17)
1.26 (0.14 to 2.36)	-0.04 (-1.25 to 1.10)	0.07 (-0.97 to 1.07)	ThuLEP	24.08 (8.82 to 39.63)	-0.66 (-19.61 to 17.04)	20.16 (0.20 to 39.98)	19.23 (1.61 to 36.80)
1.43 (0.55 to 2.23)	0.13 (-0.83 to 1.05)	0.25 (-0.73 to 1.13)	0.17 (-1.32 to 1.57)	TmLRP	-24.74 (-40.89 to -7.34)	-3.92 (-21.29 to 14.28)	-4.85 (-19.24 to 10.05)
-0.36 (-3.58 to 2.71)	-1.66 (-5.01 to 1.41)	-1.54 (-4.93 to 1.53)	-1.61 (-5.01 to 1.51)	-1.79 (-4.92 to 1.34)	HoLRP		
0.86 (-0.53 to 2.28)	-0.44 (-1.74 to 0.89)	-0.32 (-1.74 to 1.12)	-0.39 (-2.01 to 1.41)	-0.57 (-2.11 to 1.14)	1.22 (-2.04 to 4.77)	HoLAP	20.82 (-0.35 to 42.92)
1.12 (-0.13 to 2.50)	-0.18 (-1.59 to 1.16)	-0.06 (-1.42 to 1.41)	-0.14 (-1.88 to 1.63)	-0.31 (-1.86 to 1.42)	1.48 (-1.82 to 5.10)	0.26 (-1.65 to 2.16)	19.89 (1.75 to 39.63)
2.87 (1.82 to 3.97)	1.57 (0.43 to 2.73)	1.69 (0.55 to 2.85)	1.62 (0.03 to 3.19)	1.44 (0.20 to 2.87)	3.23 (-0.06 to 6.61)	2.01 (0.16 to 3.68)	1.75 (0.08 to 3.43)
							DiLVP (-21.02 to 17.99)

Table 7. The rank of all treatments (efficacy and safety). Abbreviations: CT, catheter removal time; HT, hospital time; US, urethral stricture; OT, operative time

	IPSS 6months mean(95%CI)	Qmax 6 months mean(95%CI)	IPSS 12 months mean(95%CI)	Qmax 12 months mean(95%CI)	US mean(95%CI)	OT mean(95%CI)	CT mean(95%CI)	HS mean(95%CI)
Rank								
TURP	3.27(1.00,6.00)	3.72(2.00,6.00)	4.94(3.00,7.00)	3.88(3.00,6.00)	5.75(4.00,7.00)	1.87(1.00,3.00)	8.27(7.00,9.00)	7.61(6.00,8.00)
PVP	5.18(2.00,7.00)	4.95(3.00,7.00)	4.33(2.00,7.00)	4.76(3.00,6.00)	3.34(2.00,6.00)	4.78(3.00,6.00)	4.21(2.00,7.00)	2.79(1.00,5.00)
HoLEP	3.89(1.00,7.00)	1.95(1.00,4.00)	1.94(1.00,5.00)	1.24(1.00,3.00)	4.85(2.00,7.00)	5.67(4.00,7.00)	4.90(2.00,7.00)	4.58(2.00,7.00)
ThuLEP						7.38(66.00,8.00)	4.49(2.00,8.00)	
TmLRP	3.68(1.00,7.00)	3.11(1.00,7.00)	3.92(1.00,7.00)	4.11(2.00,6.02)	3.15(1.00,7.00)	2.21(1.00,4.00)	3.73(2.00,7.00)	2.73(1.00,7.00)
HoLRP	2.37(1.00,7.00)	2.85(1.00,7.00)	4.53(1.00,7.00)	1.91(1.00,3.00)	5.26(1.00,7.00)		7.53(2.00,9.00)	4.45(1.00,8.00)
HoLAP	6.20(1.00,7.00)	5.83(1.00,7.00)	2.52(1.00,7.00)	5.55(2.00,7.00)	1.85(1.00,7.00)	7.39(5.00,8.00)	5.81(2.00,9.00)	2.95(1.00,7.00)
DiLEP						3.26(1.00,7.00)	4.96(2.00,8.00)	5.95(1.00,8.00)
DiLVP	3.41(1.00,7.00)	5.58(2.00,7.00)	5.81(2.00,7.00)	6.55(5.00,7.00)	3.80(1.00,7.00)	3.44(1.00,6.00)	1.11(1.00,2.00)	3.95(1.00,7.00)
Best								
TURP	0.05(0.00,1.00)	0.00(0.00,0.00)	0.00(0.00,0.00)	0.00(0.00,0.00)	0.00(0.00,0.00)	0.36(0.00, 1.00)	0.00(0.00,0.00)	0.00(0.00,0.00)
PVP	0.01(0.00,0.00)	0.00(0.00,0.00)	0.01(0.00,0.00)	0.00(0.00,0.00)	0.02(0.00,0.00)	0.00(0.00, 0.00)	0.00(0.00,0.00)	0.11(0.00,1.00)
HoLEP	0.05(0.00,1.00)	0.36(0.00,1.00)	0.68(0.00,1.00)	0.83(0.00,1.00)	0.02(0.00,0.00)	0.00(0.00, 0.00)	0.00(0.00,0.00)	0.01(0.00,0.00)
ThuLEP						0.00(0.00, 0.00)	0.01(0.00,0.00)	
TmLRP	0.19(0.00,1.00)	0.28(0.00,1.00)	0.08(0.00,1.00)	0.01(0.00,0.00)	0.18(0.00,1.00)	0.30(0.00,1.00)	0.01(0.00,0.00)	0.37(0.00,1.00)
HoLRP	0.51(0.00,1.00)	0.32(0.00,1.00)	0.09(0.00,1.00)	0.15(0.00,1.00)	0.03(0.00,1.00)		0.02(0.00,0.00)	0.04(0.00,1.00)
HoLAP	0.03(0.00,1.00)	0.03(0.00,1.00)	0.13(0.00,1.00)	0.01(0.00,0.00)	0.64(0.00,1.00)	0.00(0.00,0.00)	0.01(0.00,0.00)	0.31(0.00,1.00)
DiLEP						0.22(0.00,1.00)	0.02(0.00,0.00)	0.03(0.00,1.00)
DiLVP	0.16(0.00,1.00)	0.01(0.00,0.00)	0.01(0.00,0.00)	0.00(0.00,0.00)	0.11(0.00,1.00)	0.12(0.00,1.00)	0.92(0.00,1.00)	0.14(0.00,1.00)

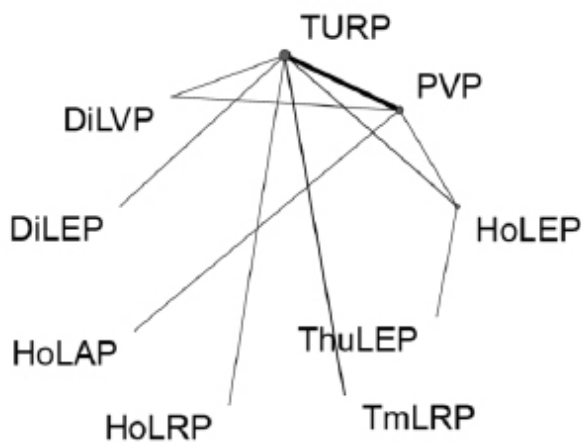


Figure 2. Network of Treatment Comparisons (Thickness of connecting lines indicates the number of available comparisons. The size of the nodes indicates the number of trials that study the treatments)

(Table 1); 15 (1,754 patients) reported the Qmax at 6 months and 15 (1,586 patients) at 12 months. Overall, 17 reports (2,033 patients) described operative time, 21 (2559 patients) catheter removal time, 17 (2,236 patients) hospital stay time and 19 (2,420 patients) urethral

stricture. Statistical heterogeneity was moderate (Table 2), although for some comparisons, I² was > 50%, for high heterogeneity, so we chose a Bayesian framework for the random-effects NMA (Borenstein et al., 2010). We found no inconsistency between direct and indirect comparisons.

Surgeries for BHP ranked by outcome

At 6 months, Qmax was lower for PVP than HoLEP (95% CI -7.06 to -0.12) and was higher for HoLEP than HoLRP (95% CI 3.65 to 8.34) (Table 3). For IPSS at 12 months, surgeries did not significantly differ (Table 4). At 12 months, Qmax was lower for TURP than HoLEP (95% CI -3.84 to -1.04) and TmLRP (95% CI -9.16 to -0.33) but higher than DiLVP (0.49 to 4.98). Qmax was lower for PVP than HoLEP (95% CI -5.46 to -1.23) and TmLRP (-10.47 to -0.80) and higher for HoLEP than DiLEP (95% CI 2.44 to 7.64) and TmLRP than HoLAP (95% CI 0.85 to 13.12) and DiLEP (95% CI 2.42 to 12.70).

Urethral stricture did not differ among treatments (Table 5). Hospital stay was longer with TURP than PVP (95% CI 1.13 to 2.41), HoLEP (95% CI 0.49 to 1.97), TmLRP (95% CI 0.28 to 3.45) and HoLAP (95% CI 0.19 to 3.43) and for HoLEP than TmLRP (95% CI 0.10 to 2.41).

Operative time was shorter with TURP than PVP

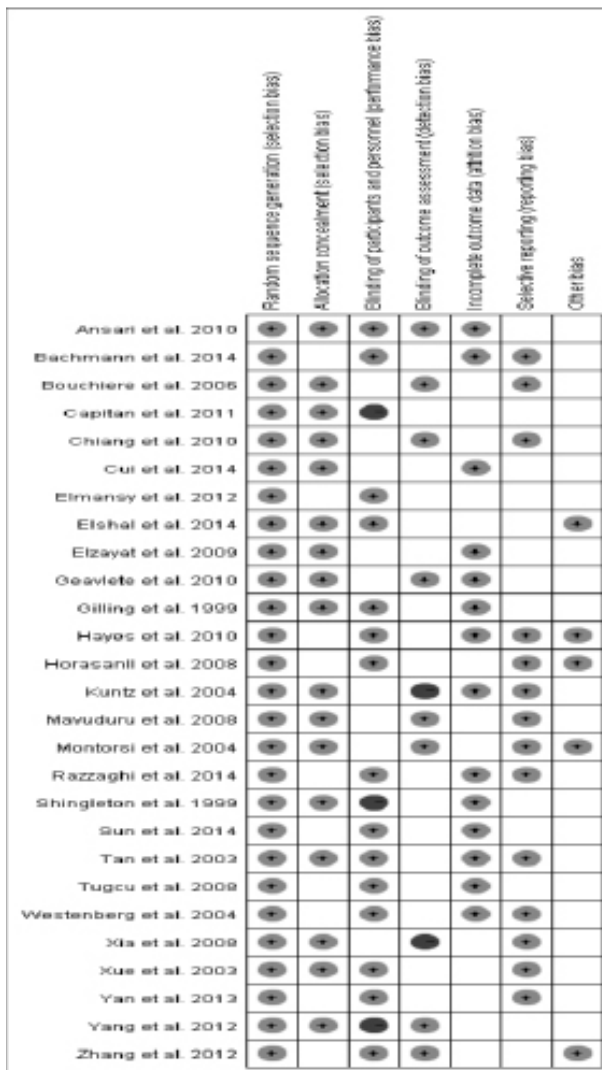


Figure 3. Quality Evaluation of Randomized Controlled Trials

(95% CI -15.77 to -7.24), HoLEP (95% CI -19.84 to -8.55), ThuLEP (95% CI -37.51 to -13.10) and HoLAP (95% CI -40.03 to -11.65) (Table 6). It was shorter with PVP than ThuLEP (95% CI -26.23 to -0.66) and HoLAP (95% CI -27.68 to -0.67); and TmLRP than HoLAP (95% CI -40.89 to -7.34). Operative time was longer with PVP than TmLRP (95% CI 0.46 to 20.15); HoLEP than TmLRP (95% CI 2.78 to 23.22); ThuLEP than TmLRP (95% CI 8.82 to 39.63), DiLEP (95% CI 0.20 to 39.98) and DiLVP (95% CI 1.61 to 36.80); and HoLAP than DiLVP (95% CI 1.75 to 39.63).

Catheter removal time was longer with TURP than PVP (94% CI 0.91 to 1.67), HoLEP (95% CI 0.75 to 1.63), ThuLEP (95% CI 0.14 to 2.36), TmLRP (95% CI 0.55 to 2.23) and DiLVP (95% CI 1.82 to 3.97) and PVP than DiLVP (95% CI 0.43 to 2.73); HoLEP than DiLVP (95% CI 0.55 to 2.85); ThuLEP than DiLVP (95% CI 0.03 to 3.19); TmLRP than DiLVP (95% CI 0.20 to 2.87); HoLAP than DiLVP (95% CI 0.16 to 3.68); and DiLEP than DiLVP (95% CI 0.08 to 3.43).

We used WinBUGS 1.4.3 to rank treatments (Schmid et al., 2013) (Table 7). For IPSS at 6 months, the order was HoLRP > TURP > DiLEP and at 12 months, HoLEP

> HoLRP > TURP. For Qmax at 6 months, the order was HoLEP > HoLRP > TmLRP and at 12 months, HoLEP > HoLRP > PVP. The order for operative time was TURP > TmLRP > DiLEP; for catheter removal time, DiLEP > TmLRP > PVP; for length of hospital stay, TmLRP > PVP > HoLAP; and for urethral stricture, HoLAP > TmLRP > PVP.

Discussion

Our NMA provided evidence-based hierarchies for the efficacy and safety of 8 laser surgeries and TURP for BHP. We integrated direct and indirect evidence from RCTs to compare the efficacy and safety of the 9 surgeries.

Our shortcoming was that we did not reported the powers of the surgeries in that we considered the surgeries with different powers as the same surgeries (e.g., we considered PVP-80w and PVP-120w as the same surgery) and some comparisons had few RCTs (e.g., DiLVP and ThuLEP), which may indicate bias when comparing the efficacy and safety of the surgeries.

Although TURP is considered the gold standard surgery for BPH, its efficacy and safety was not the best among the 9 surgeries. Catheter removal and hospital stay times were shorter for PVP than TURP. A conventional meta-analysis reported that blood transfusion were significantly less likely with PVP than TURP (Thangasamy et al., 2012). At 12 months, Qmax was higher and catheter removal time shorter for TmLRP than TURP; catheter removal time was shorter for DiLVP than TURP. We found no difference between DiLEP and TURP in operative time, catheter removal time or length of hospital stay. As well, at 12 months, Qmax was lower for TURP than HoLEP and TmLRP. Hospital stay was longer with TURP than PVP, TmLRP and HoLAP and catheter removal time was longer with TURP than PVP, HoLEP, ThuLEP, TmLRP and DiLVP.

Some studies (Elzayat et al., 2005; Rij and Gilling, 2012) reported that HoLEP may the new gold standard for BPH. A conventional meta-analysis (Tan et al., 2007) reported that at 12 months, Qmax and IPSS was better with HoLEP than TURP ($p < 0.0001$ and $p = 0.01$). HoLEP was associated with less blood loss ($p = 0.001$) and required shorter catheterization time ($p < 0.0001$) and hospital stay ($p = 0.001$) and lower blood transfusion rate ($p = 0.04$). We found HoLEP best in terms of Qmax at 6 and 12 months and IPSS at 12 months. Operative time was longer with HoLEP than TURP, some conventional meta-analyses also found the same results (Tan et al., 2007; Zhao et al., 2011). HoLEP may remove more tissue than TURP (Tan et al., 2003; Montorsi et al., 2004), and HoLEP requires extra time for fragmentation of prostatic lobes into pieces small enough to be evacuated through the resectoscope sheath (Montorsi et al., 2004).

In brief, although TURP is considered the gold standard surgery for BPH, our NMA comparing 8 other BHP laser treatments and TURP showed that it may not be the best in terms of efficacy and safety, HoLEP is more competitive, IPSS at 12 months and Qmax at 6 months and 12 months especially.

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