Original Article

Int Neurourol J 2013;17:59-66
http://dx.doi.org/10.5213/inj.2013.17.2.59
pISSN 2093-4777 · eISSN 2093-6931

International Neurourology Journal
INJ

Transurethral Procedures for Lower Urinary Tract Symptoms Resulting From Benign Prostatic Enlargement: A Quality and Meta-Analysis

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Purpose: Thanks to advancements in surgical techniques and instruments, many surgical modalities have been developed to replace transurethral resection of the prostate (TURP). However, TURP remains the gold standard for the surgical treatment of benign prostatic hyperplasia (BPH). We conducted a meta-analysis on the efficacy and safety of minimally invasive surgical therapies for BPH compared with TURP.
Methods: This meta-analysis used a Medline search assessing the period from 1997 to 2011. A total of 784 randomized controlled trials were identified in an electronic search. Among the 784 articles, 36 randomized controlled trials that provided the highest level of evidence (level 1b) were included in the meta-analysis. We also conducted a quality analysis of selected articles.
Results: Only 2 articles (5.56%) were assessed as having a low risk of bias by use of the Cochrane collaboration risk of bias tool. On the other hand, by use of the Jadad scale, there were 26 high-quality articles (72.22%). Furthermore, 28 articles (77.78%) were assessed as high-quality articles by use of the van Tulder scale. Holmium laser enucleation of the prostate (HoLEP) showed the highest reduction of the International Prostate Symptom Score compared with TURP ($P < 0.0001$). Bipolar TURP, bipolar transurethral vaporization of the prostate, HoLEP, and open prostatectomy showed superior outcome in postvoid residual urine volume and maximum flow rate. The intraoperative complications of the minimally invasive surgeries had no statistically significant inferior outcomes compared with TURP. Also, there were no statistically significant differences in any of the modalities compared with TURP.
Conclusions: The selection of an appropriate surgical modality for BPH should be assessed by fully understanding each patient's clinical conditions.

Keywords: Prostatic hyperplasia; Holmium; Lasers; Potassium titanylphosphate; Transurethral resection of prostate; Meta-analysis

INTRODUCTION

Benign prostatic hyperplasia (BPH), which causes lower urinary tract symptoms (LUTS), is one of the most common diseases of aging men [1]. LUTS can reduce quality of life by impeding normal activities and causing complications such as acute

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Submitted: March 25, 2013 / Accepted after revision: May 2, 2013

urinary retention or urinary tract infection. BPH is histologically observed in about half of men in their 60s and in most men aged 80 and older [2]. Nowadays, various medications are used to treat LUTS resulting from BPH (LUTS/BPH); these include 5-alpha-reductase inhibitors (5-ARIs), alpha-adrenergic blockers, and others. Moreover, many surgical treatment methods have been introduced, such as resection or enucleation.

Currently, the gold standard surgical treatment for LUTS/BPH is transurethral resection of the prostate (TURP) [3,4]. However, TURP is associated with complications including bleeding, pain, infection, urethral stricture, bladder neck contraction, erectile dysfunction, incontinence, and retrograde ejaculation [5]. Therefore, many endoscopic surgical methods have been suggested to replace TURP as the new standard [6]. There has been a continuous rise in the use of minimally invasive surgical therapies for LUTS/BPH, including bipolar TURP, bipolar transurethral vaporization of the prostate (TUVP), holmium laser enucleation of the prostate (HoLEP), and potassium-titanyl-phosphate (KTP) laser vaporization of the prostate. So far, numerous articles have reported on comparisons of these new techniques with TURP. Ahyai et al. [6] reported a meta-analysis on functional outcomes and complications of transurethral prostatectomy for LUTS/BPH. According to those authors, many minimally invasive surgical therapies for LUTS/BPH showed statistically comparable efficacy and overall morbidity to TURP. However, that report included randomized controlled trials published from 1997 to 2009.

Therefore, we conducted a meta-analysis on the efficacy and safety of minimally invasive surgical therapies for LUTS/BPH compared with TURP by analyzing more recent articles that were published from 2010 to 2011. In addition, we assessed the quality of these articles by using the Jadad scale, the van Tulder scale (VTS), and Cochrane collaboration risk of bias tool (CCRBT).

MATERIALS AND METHODS

Searching Strategy

This meta-analysis used a Medline search assessing the period from 1997 to 2011. We searched published articles by using MeSH phrases such as "benign prostatic hyperplasia," "enlargement," and "obstruction"; "minimally invasive surgical therapy"; "randomized controlled trial [Publication Type]"; and the specific TURP name. There were no limitations on languages.

Study Selection

A total of 784 randomized controlled trials were identified in an electronic search. Among the 784 articles, 36 randomized controlled trials that provided the highest level of evidence (level 1b) were included in the meta-analysis. Studies that were not randomized or that had no comparator were excluded.

Data Extraction

We collected the following data: comparator; name of first author; year of publication; number of patients in each group; follow-up period; baseline data, including age, prostate volume (cm^3), International Prostate Symptom Score (IPSS), quality of life (QoL) score, postvoiding residual urine volume (PVR; mL), and maximum flow rate (Qmax; mL/sec) before the procedure (Table 1); perioperative outcomes, including operative time (min), weight of resected tissue (g), and length of catheter use (day); functional outcomes, including IPSS and Qmax after the surgery; and complications (Table 2).

Quality Analysis

We assessed the quality of the selected articles by using the Jadad scale, VTS, and CCRBT [7]. All quality assessments of articles were performed by two reviewers. If there were different outcomes, the two reviewers and a third reviewer resolved the discrepancy in the results through discussion.

Statistical Analysis

The primary endpoint of the present analysis was functional outcomes, including IPSS/QoL and Qmax/PVR; perioperative results, including operative time (min) and length of catheter use (day); and incidence rate of complications, including bleeding, blood transfusion, conversion to TURP, capsule perforation, transurethral resection syndrome, acute urinary retention, clot retention, secondary apical resection, secondary coagulation revision, secondary bleeding, infection, urethral stricture, bladder neck stenosis, urgency, stress urinary incontinence, and reoperation/intervention requirement. Pooled odds ratios and 95% confidence intervals were calculated for the dichotomous and continuous outcome data between the various operative methods and TURP, respectively. The Q-statistic was used to analyze heterogeneity [8]. If $I2 > 50\%$, we considered it as heterogeneous and a random effect model was performed. IBM SPSS ver. 18.0 (IBM Co., Armonk, NY, USA) and SAS ver. 9.1.3 (SAS Institute, Cary, NC, USA) were used for the statistical analysis. All tests were two-sided, with a significance level of 0.05.

 http://dx.doi.org/10.5213/inj.2013.17.2.59

Table 1. Summary of (mean) baseline characteristics from included randomised trials comparing minimally invasive therapies with transurethral resection of the prostate

Publication year	Author[a)]	Comparator	No. of patients	Follow-up (yr)	Age (yr)	Prostate volume (cm^3)	IPSS	QoL	Qmax (mL/sec)	PVR (mL)
2011	Geavlete et al. [S-1]	BPVP vs. TURis	170; 170; 170	1.5	N/A	54.1; 53.7; 54.8	24.3; 24.0; 24.2	4.3; 4.5; 4.3	6.6; 6.1; 6.4	91; 96; 88
2011	Fagerstroml et al. [S-2]	Bipolar TURP	90; 95; 185	1.5	69.5; 72.7	55.6; 58.2	21.7; 20.4	3.9; 3.7	N/A	N/A
2011	Fayad et al. [S-3]	HoLEP vs. Bipolar TURP	30; 30	0.5	60.0; 61.2	76.5; 80.6	22.6; 22.2	N/A	7.4; 6.9	N/A
2010	Chen et al. [S-4]	Bipolar TURP (TURis)	50; 50	2.0	69.7; 71.2	60.2; 59.1	22.8; 21.8	N/A	7.1; 7.9	73.1; 80
2010	Zhao et al. [S-5]	Plasmakinetic enucleation	102; 102	3.0	67.3; 67.8	69.2; 67.5	23.2; 22.4	4.5; 4.8	8.3; 8.0	92; 97
2010	Al-Ansari et al. [S-6]	KTP	60; 60	3.0	66.3; 67.1	61.8; 60.3	27.2; 27.9	N/A	6.9; 6.4	53.2; 57
2010	Simforoosh et al. [S-7]	Open	51; 49	1.0	71.7; 61.0	47.9; 44.4	27.1; 27.1	N/A	7.0; 8.1	62; 47
2010	Ou et al. [S-8]	Open	34; 35	1.0	71.3; 70.9	138.4; 131.0	23.1; 21.7	4.4; 4.3	5.0; 6.2	80.3; 92.7
2010	Elmansy et al. [S-9]	HoLEP vs. PVP	57; 52	4.0	72.7; 71.6	33.1; 37.3	20; 18.4	3.8; 3.6	6.7; 6.4	205; 215
2008	Horasanli et al. [S-10]	KTP	39; 37	0.5	69.2; 68.3	86; 88	18.9; 20.2	N/A	8.6; 9.2	183.0; 176.9
2008	Alivizatos et al. [S-11]	KTP vs. open	65; 60	1.0	74.0; 67.5	93.0; 96.0	20.0; 21.0	3.0; 3.0	8.6; 8.0	97.0; 89.0
2008	Iori et al. [S-12]	Bipolar TURP	26; 25	1.0	65.0; 63.0	49.0; 48.0	21.0; 20.0	3.0; 3.6	7.0; 8.7	99.0; 96.0
2008; 2002	Kuntz and Lehrich [S-13,14]	HoLEP vs. open	60; 60	5.0	69.2; 71.2	114.6; 113.0	22.1; 21.0	N/A	3.8; 3.6	280
2007	Michielsen et al. [S-15]	Bipolar TURP	118; 120	1.5	73.8; 73.1	N/A	N/A	N/A	N/A	N/A
2007; 2006	de Sio et al. [S-16]	Bipolar TURP	35; 35	3.0	59.0; 61.0	51.6; 47.5	24.2; 24.3	4.2; 3.9	7.1; 6.9	80.0; 75.0
2007	Ho et al. [S-17]	Bipolar TURP	48; 52	1.0	66.6; 66.5	56.5; 54.8	22.6; 24.6	N/A	6.8; 6.5	N/A
2007	Kaya et al. [S-18]	Bipolar TUVP	25; 15	3.0	67.2; 66.0	50.0; 51.0	21.0; 22.0	N/A	6.0; 6.0	N/A
2007; 2004	Kuntz and Lehrich [S-19]/ Ahyai and Leihrich [S-20]	HoLEP	100; 100	3.0	68.0; 68.7	53.5; 49.9	22.1; 21.4	N/A	45.9; 5.9	238.0; 216.0
2006	Patankar et al. [S-21]	Bipolar TURP	53; 51	0.1	64.0; 62.0	51.3; 52.3	23.3; 23.7	N/A	5.9; 6.4	N/A
2006	Nuhoglu et al. [S-22]	Bipolar TURP	27; 30	1.0	64.6; 65.2	47.0; 49.0	17.6; 17.3	N/A	6.9; 7.3	96.0; 88.0
2006	Gupta et al. [S-23]	HoLEP	50; 50	1.0	65.8; 65.7	57.9; 59.8	23.4; 23.3	N/A	5.2; 4.5	112.0; 84.0
2006	Neill et al. [S-24]	HoLEP	30; 30	2.0	71.7; 70.3	77.8; 70.0	26.0; 23.7	4.8; 4.7	8.4; 8.3	N/A
2006	Naspro et al. [S-25]	HoLEP vs. open	41; 39	2.0	66.3; 67.3	113.3; 124.2	20.1; 21.6	4.1; 4.4	7.8; 8.3	N/A
2006	Bouchiers-Hayes et al. [S-26]	KTP	38; 38	1.0	65.2; 66.2	42.4; 33.2	N/A	N/A	N/A	147.0; 119.0
2006	Hon et al. [S-27]	Bipolar TUVP	81; 79	0.7	66.1; 68.1	38.0; 40.0	21.3; 20.6	4.2; 4.3	12.0; 11.9	147.0; 182.0
2005	Singh et al. [S-28]	Bipolar TURP	30; 30	0.3	68.9; 67.9	24.1; 27.9	20.5; 21.6	4.6; 4.4	5.8; 5.1	124.0; 136.0
2005	Seckiner et al. [S-29]	Bipolar TURP	24; 24	1.0	61.2; 63.9	49.4; 41.4	24.1; 23.2	4.4; 4.7	8.5; 8.3	88.0; 138.0
2005	Fung et al. [S-30]	Bipolar TURP	21; 30	0.3	72.5; 73.0	N/A	15.8; 19.4	3.6; 3.6	N/A	N/A
2005	Tefekli et al. [S-31]	Bipolar TUVP	51; 50	1.0	68.7; 69.4	50.1; 50.4	21.3; 20.4	N/A	7.8; 8.3	N/A
2004	Yang et al. [S-32]	Bipolar TURP	58; 59	0.3	N/A	46; 49	20.9; 21.6	3.7; 4.0	10.4; 10.9	99.0; 150
2004	Montorsi et al. [S-33]	HoLEP	52; 48	1.0	65.1; 64.5	70.3; 56.2	21.6; 21.9	4.6; 4.7	8.2; 7.8	N/A
2003	Dumsumir et al. [S-34]	Bipolar TUVP	30; 21	1.0	63.0; 60.0	36.0; 42.0	24.0; 17.0	N/A	9.6; 10.4	112.0; 96.0

IPSS, International Prostate Symptom Score; QoL, quality of life; Qmax, maximum flow rate; PVR, postvoid residual urine volume; BPVP, bipolar plasma vaporization of the prostate; TURis, transurethral resection of prostate in saline; N/A, not available; TURP, transurethral resection of prostate; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate; PVP, plasma vaporization of the prostate; TUVP, transurethral vaporisation of the prostate.
[a)]Supplementary material for authors can be found via http://www.einj.org/src/sm/inj-17-59-s001.pdf.

RESULTS

Quality Analysis of Selected Articles

Among the 36 articles, only 2 articles (5.56%) were assessed as having a low risk of bias, 7 articles (19.44%) were assessed as having a moderate risk of bias, and 27 articles (0.75%) were evaluated as having a high risk of bias by use of the CCRBT. On the other hand, by use of the Jadad scale, there were 26 high-quality articles (72.22%). Furthermore, 28 articles (77.78%) were assessed as high-quality articles by use of the VTS.

Meta-Analysis of Functional Outcomes

IPSS (Fig. 1) and QoL (Fig. 2)

Only KTP laser vaporization of the prostate showed an inferior outcome compared with TURP (P = 0.0272). Otherwise, HoLEP showed the highest reduction of the IPSS compared with TURP

Table 2. Summary of (mean) outcome data from included randomised studies comparing minimally invasive surgical therapies with transurethral resection of the prostate

Author[a)]	Comparator	Operating time (min)	Resected tissue (gm)	Catheterization time (day)	IPSS	QoL	Qmax (mL/sec)	PVR (mL)
Geavlete et al. [S-1]	BPVP vs. TURis vs. TURP	39.7; 52.1; 55.6	N/A	0.9; 1.9; 3.0	5.0; 7.9; 8.3	1.0; 1.3; 1.5	23.7; 20.6; 20.2	29; 31; 33
Fagerstroml et al. [S-2]	Bipolar TURP	62; 66	27.3; 26.3	0.8; 0.8	7.1; 7.6	0.9; 1.1	N/A	N/A
Fayad et al. [S-3]	HoLEP vs. Bipolar TURP	110.5; 76.5	55.9; 65.6	N/A	5.5; 5.3	N/A	20.8; 20.5	20.3; 25.6
Chen et al. [S-4]	Bipolar TURP (TURis)	59; 60	40; 38.9	N/A	3.7; 3.8	N/A	25.5; 24.8	N/A
Zhao et al. [S-5]	Plasmakinetic enucleation	62.8; 55.3	56.4; 43.8	2.2; 3.4	2.4; 4.3	0.6; 1.6	28.8; 25.1	5.0; 5.4
Al-Ansari et al. [S-6]	KTP	89; 80	N/A	1.4; 2.7	10.9; 9.2	N/A	17.2; 20	12.5; 10.5
Simforoosh et al. [S-7]	Open	N/A	34.5; 31.0	7; 5	4.8; 6.7	2.3; 2.8	18.1; 16.1	2.0; 2.5
Ou et al. [S-8]	Open	109.5; 103.7	116.8; 69.7	7.5; 4.1	2.8; 8.1	1.26; 2.5	16.4; 12.5	9.12; 27.3
Elmansy et al. [S-9]	HoLEP vs. PVP	69.8; 55.5	N/A	2.1; 1.6	5.9; 6.6	1.1; 1.2	17.7; 18.5	38.8; 43.9
Horasanli et al. [S-10]	KTP	87; 51	N/A	1.7; 3.9	13.1; 6.4	N/A	13.3; 20.7	79; 23
Alivizatos et al. [S-11]	KTP vs. Open	80.0; 50.0	0.0; 73.5	1.0; 5.0	9.0; 8.0	1.0; 1.0	16.0; 15.1	17; 12
Iori et al. [S-12]	Bipolar TURP	39.1; 31.7	N/A	1.0; 1.3	7.0; 6.7	1.0; 1.0	24.2; 23.2	20.0; 27.0
Kuntz and Lehrich [S-13,14]	HoLEP vs. Open	135.9; 90.6	93.7; 96.4	1.8; 8.1	3.0; 3.2	N/A	24.3; 24.4	10.6; 5.3
Michielsen et al. [S-15]	Bipolar TURP	56.0; 44.0	21.0; 21.3	4.0; 4.5	N/A	N/A	N/A	N/A
de Sio et al. [S-16]	Bipolar TURP	49.0; 53.0	20.0; 24.0	3.0; 4.2	6.8; 6.2	1.0; 0.8	20.5; 21.5	25.0; 20.0
Ho et al. [S-17]	Bipolar TUVP	N/A	N/A	N/A	7.6; 14.4	N/A	5.7; 21.8	N/A
Kaya et al. [S-18]	HoLEP	94.6; 73.8	35.9; 37.2	1.0; 2.0	3.0; 10.0	N/A	29.0; 27.5	8; 20
Kuntz and Lehrich [S-19]/ Ahyai and Leihrich [S-20]	Bipolar TURP	50.0; 57.9	N/A	0.8; 1.8	6.1; 7.7	N/A	19.2; 20.7	N/A
Patankar et al. [S-21]	Bipolar TURP	55.0; 52.0	N/A	1.8; 3.2	5.4; 4.7	N/A	17.1; 17.9	N/A
Nuhoglu et al. [S-22]	HoLEP	75.4; 62.6	17.2; 24.2	1.2; 2.0	5.2; 5.6	N/A	25.1; 23.7	20.0; 20.0
Gupta et al. [S-23]	HoLEP	62.1; 33.1	40.4; 24.7	0.7; 1.9	6.1; 5.2	1.25; 1.3	21.0; 19.0	33.7; 51.8
Neill et al. [S-24]	HoLEP vs. Open	72.1; 58.3	59.3; 87.9	1.5; 4.1	7.9; 8.1	1.5; 1.66	19.2; 20.1	N/A
Naspro et al. [S-25]	KTP	31.3; 30.2	N/A	0.51; 1.9	12.0; 12.4	N/A	19.9; 20.6	37; 27
Bouchiers-Hayes et al. [S-26]	Bipolar TUVP	32.6; 28.5	0.0;21.5	N/A	7.7; 6.9	1.7; 1.5	25.6; 23.5	64.0; 69.0
Hon et al. [S-27]	Bipolar TURP	39.3; 36.9	24.0; 27.6	2.5; 3.4	5.3; 6.2	1.1; 1.0	19.0; 17.8	N/A
Singh et al. [S-28]	Bipolar TURP	52.9; 52.9	36.6; 31.9	3.1; 3.1	8.7; 8.3	1.8; 2.0	18.8; 15.7	N/A
Seckiner et al. [S-29]	Bipolar TURP	36.6; 32.9	18.6; 25.1	1.1; 1.2	7.0; 9.7	N/A	16.6; 14.7	N/A
Fung et al. [S-30]	Bipolar TUVP	40.3; 57.8	N/A	2.3; 3.8	7.9; 7.3	N/A	17.2; 16.9	N/A
Tefekli et al. [S-31]	Bipolar TURP	46.0; 55.0	N/A	2.7; 3.2	10.8; 11.1	2.1; 2.2	17.1; 14.8	13.9; 34.5
Yang et al. [S-32]	HoLEP	74.0; 57.0	36.1; 25.4	1.3; 2.4	4.1; 3.9	1.4; 0.8	25.1; 24.7	N/A
Montorsi et al. [S-33]	Bipolar TUVP	33.0; 26.0	0.0; 8.0	0.8; 0.7	6.0; 5.0	N/A	18.0; 16.0	90.0; 80.0

IPSS, International Prostate Symptom Score; QoL, quality of life; Qmax, maximum flow rate; PVR, postvoid residual urine volume; BPVP, bipolar plasma vaporization of the prostate; TURis, transurethral resection of prostate in saline; TURP, transurethral resection of prostate; N/A, not available; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate; PVP, plasma vaporization of the prostate; TUVP, transurethral vaporisation of the prostate.
[a)]Supplementary material for authors can be found via http://www.einj.org/src/sm/inj-17-59-s001.pdf.

($P < 0.0001$). Moreover, only HoLEP showed a higher QoL, although it was not statistically significant ($P = 0.1252$).

Maximum flow rate (Fig. 3) and postvoid residual urine volume (Fig. 4)

Only KTP showed an inferior outcome in Qmax and PVR ($P = 0.1407$, $P = 0.0058$). However, bipolar TURP, bipolar TUVP, HoLEP, and open prostatectomy showed a superior outcome in Qmax and PVR. Open prostatectomy and HoLEP could not be statistically analyzed for PVR owing to insufficient data.

Meta-Analysis of Complications Of Surgery

Intraoperative complications (Fig. 5)

No surgical methods showed statistically significant inferior outcomes compared with TURP. However, HoLEP showed the highest complication rate ($P = 0.0710$) and KTP showed a sta-

 http://dx.doi.org/10.5213/inj.2013.17.2.59

tistically significantly lower complication rate than TURP (P < 0.0001). HoLEP showed the highest incidence of bladder mucosal injury, and TURP showed the highest incidence of intraoperative transfusion (Table 3).

Perioperative complications (Fig. 6)

KTP and HoLEP showed statistically significantly inferior outcomes compared with TURP (P < 0.0001, P = 0.0342, respectively). Acute urinary retention, secondary apical resection, and febrile urinary tract infection occurred most commonly with KTP. TURP showed the highest occurrence rate of clot retention and hematuria episodes (Table 4).

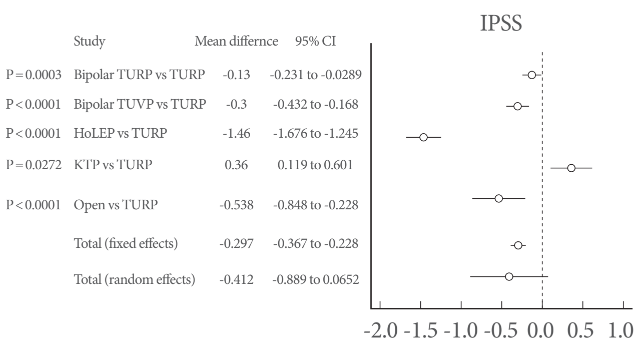

Fig. 1. Forest plot of International Prostate Symptom Score (IPSS). CI, confidence interval; TURP, transurethral resection of the prostate; IPSS, International Prostate Symptom Score; TUVP, transurethral vaporization of the prostate; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate.

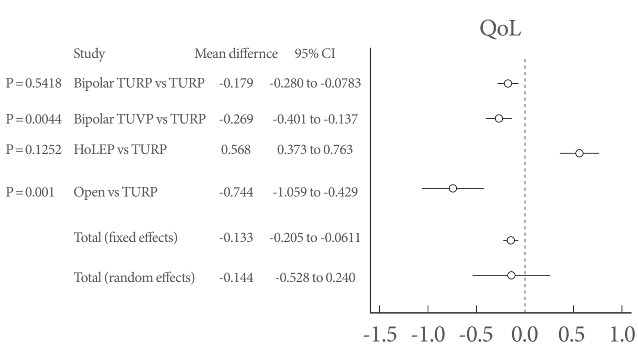

Fig. 2. Forest plot of quality of life (QoL, question 8 of the IPSS). CI, confidence interval; TURP, transurethral resection of the prostate; IPSS, International Prostate Symptom Score; TUVP, transurethral vaporization of the prostate; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate.

Late complications (Fig. 7)

There were no statistically significant differences in any of the modalities compared with TURP. However, bladder neck contracture, urethral stricture, dysuria, and reintervention episode occurred more commonly in the KTP group than in the others (Table 5).

DISCUSSION

BPH results from the proliferation of smooth muscle cells and epithelial cells in the prostatic transitional zone [9]. The treatment of LUTS/BPH is aimed at improving QoL and preventing complications such as urinary tract infection and urinary retention. Treatment methods are largely divided into surgery, medi-

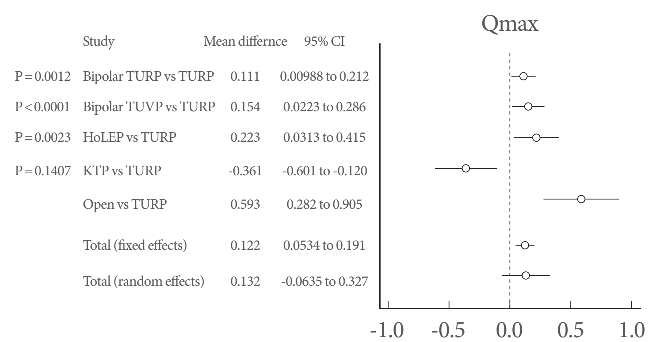

Fig. 3. Forest plot of maximum flow rate (Qmax). CI, confidence interval; TURP, transurethral resection of the prostate; IPSS, International Prostate Symptom Score; TUVP, transurethral vaporization of the prostate; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate.

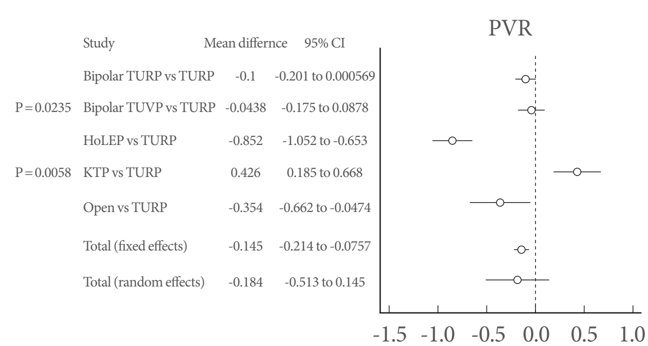

Fig. 4. Forest plot of postvoid residual urine volume (PVR). CI, confidence interval; TURP, transurethral resection of the prostate; IPSS, International Prostate Symptom Score; TUVP, transurethral vaporization of the prostate; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate.

cal treatment, and watchful waiting [10]. Watchful waiting is applicable to patients with mild symptoms or with moderate-to-severe symptoms but no complications. This treatment option requires measurement of prostate volume and Qmax annually [11]. For medical management, representative drugs are 5-ARIs and alpha-adrenergic blockers. 5-ARI lowers the serum dihydrotestosterone level and reduces the volume of the prostate [12]. Alpha-adrenergic blockers improve voiding symptoms by relaxation of smooth muscle in the prostate [13]. However, when patients have concomitant complications such as hematuria, infection, or urinary tract obstruction, surgical management is warranted [14]. Many surgical techniques have been

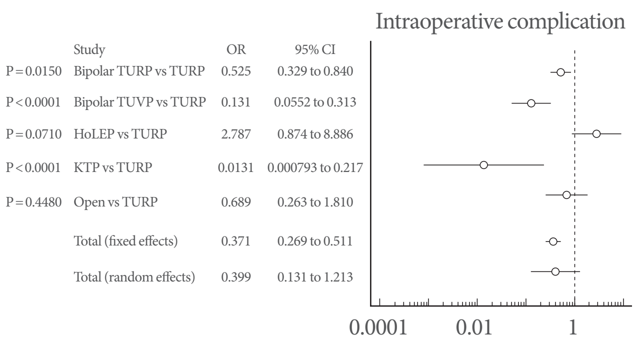

Fig. 5. Forest plot of intraoperative complications. TURP, transurethral resection of the prostate; OR, odds ratio; CI, confidence interval; TUVP, transurethral vaporization of the prostate; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate.

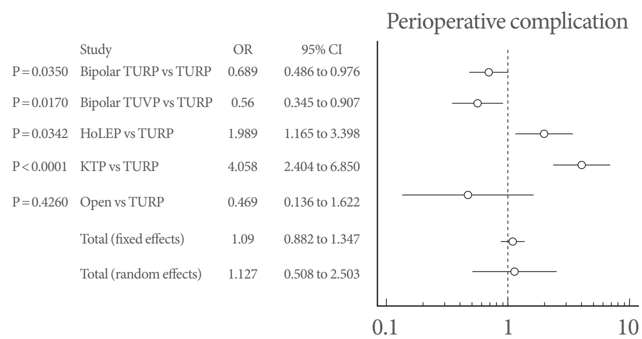

Fig. 6. Forest plot of perioperative complications. OR, odds ratio; CI, confidence interval; TURP, transurethral resection of the prostate; TUVP, transurethral vaporization of the prostate; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate.

Table 3. Intraoperative complications

Procedure	Bleeding	Capsular perforation	Conversion to TURP	Bladder mucosal injury	Transfusion	TUR syndrome	Total
TURP (%)	1.7	1.8	0	0	4.3	0.9	8.7
Bipolar TURP (%)	1.7	1.5	0	0	2	0	5.5
Bipolar TUVP (%)	0.6	0.4	0	0	0.6	0	1.6
HoLEP (%)	0	0.2	0	2.6	0	0	2.8
KTP (%)	0	0	1.9	0	0	0	1.9

TURP, transurethral resection of prostate; TUVP, transurethral vaporisation of the prostate; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate.

Table 4. Perioperative complication

Procedure	AUR	Clot retention	Secondary apical resection	Secondary coagulation	Delay bleeding	Episodes of hematuria	Urosepsis	UTI, fever	Total
TURP (%)	3.7	4.5	0.1	0.6	0.9	3.8	0.1	3.8	17.5
Bipolar TURP (%)	3.3	2.6	0	0	0.8	1.5	0	2.2	10.4
Bipolar TUVP (%)	3.9	2.4	0	0	0.9	0	0	1.3	8.5
HoLEP (%)	4.6	0	0.4	1.1	0	0	0	0.6	6.7
KTP (%)	5.5	0	1.2	0	0.4	0	0	6.7	13.8

AUR, acute urinary retention; UTI, urinary tract infection; TURP, transurethral resection of prostate; TUVP, transurethral vaporisation of the prostate; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate.

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Table 5. Late operative complication

Procedure	Bladder neck contracture	Urethral stricture	Reintervention	Secondary treatment	Transient dysuria	Urgency	Stress urinary incontinence	Total
TURP (%)	2.0	3.7	1.5	0.6	4.8	2.5	0.9	16.0
Bipolar TURP (%)	1.2	3.0	1.2	1.2	2.3	1.2	0.3	10.4
Bipolar TUVP (%)	0.7	2.6	1.5	0.6	5.2	1.9	0.2	12.7
HoLEP (%)	1.6	4.0	0.9	0	0.9	4.4	0.9	12.7
KTP (%)	5.9	4.7	6.7	0	15.7	0	0.7	33.7

TURP, transurethral resection of prostate; TUVP, transurethral vaporisation of the prostate; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate.

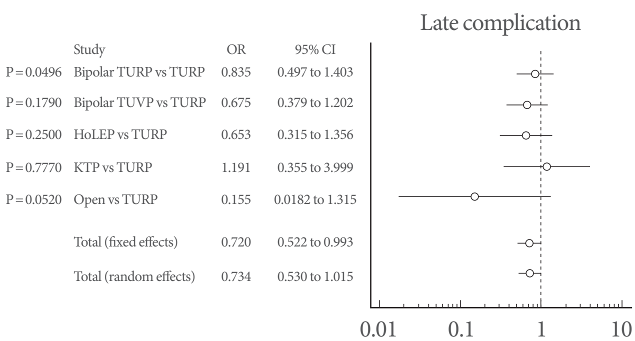

Fig. 7. Forest plot of late complications. OR, odds ratio; CI, confidence interval; TURP, transurethral resection of the prostate; TUVP, transurethral vaporization of the prostate; HoLEP, holmium laser enucleation of the prostate; KTP, potassium-titanyl-phosphate.

developed, such as open prostatectomy, HoLEP, KTP, TURP, bipolar TURP, and bipolar TUVP. Until now, TURP has remained the gold standard treatment option for LUTS/BPH [11]. However, TURP faces many challenges, such as morbidity and functional outcomes [15].

TURP

Accord to our results, TURP was one of the most effective surgical modalities for relieving the obstruction due to BPH. This method needed less reintervention and showed effectiveness for relieving the voiding symptoms, including reduction of IPSS and improvement of Qmax. However, as shown in Tables 3 and 4, TURP has many intraoperative and perioperative complications, such as bleeding, clot retention, and transfusion. Nonetheless, the late complication rate was not inferior compared with other surgical methods. Considering these results, TURP is a worthy mode of surgical intervention for treating LUTS/BPH.

Bipolar TURP

In our meta-analysis, bipolar TURP showed comparable functional outcomes to TURP. Moreover, bipolar TURP showed a shorter length of Foley catheterization and lower intraoperative and perioperative complications. However, to replace TURP, long-term, large-scale, randomized controlled trials will be needed.

HoLEP

Many articles have shown that for large prostates, HoLEP shows superior functional outcomes to open prostatectomy [16,17]. Some parameters of HoLEP, such as length of hospital stay and duration of Foley catheterization, showed supremacy to TURP. Moreover, HoLEP seemed to be effective for avoiding intraoperative and perioperative complications, even though it showed bladder mucosal injury during morcellation of resected prostate adenoma. To confirm the effectiveness and safety of HoLEP, many studies should be performed in relatively small prostates, and long-term comparative studies are needed.

KTP Laser Vaporization of the Prostate

For small to moderate prostate volume, KTP showed comparable functional outcomes, such as for Qmax, PVR, IPSS, and QoL, to TURP. Also, KTP had some benefits, such as a lower incidence of intraoperative complications compared with TURP in patients with a small to moderate prostate volume. However, KTP showed a higher incidence of late complications, such as bladder neck contracture and urethral stricture. Thus, long-term, large-scale randomized controlled studies, conducted for large prostates, should be conducted to prove the usefulness and safety of KTP.

We conducted a meta-analysis of transurethral surgeries for LUTS/BPH. It will be helpful to identify the advantages and disadvantages of each surgical modality. However, we conducted the meta-analysis without a quality analysis of the articles. This is a limitation of the present study even though we per-

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formed our analysis of the articles that showed the highest level of evidence.

In conclusion, this study showed statistically comparable efficacy and overall morbidity of transurethral surgeries compared with TURP. Functional outcomes and complications at each step varied for each modality. The selection of an appropriate surgical modality for BPH should be assessed by fully understanding each patient's clinical conditions.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

SUPPLEMENTARY MATERIALS

Supplementary material can be found via http://www.einj.org/src/sm/inj-17-59-s001.pdf.

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