Bipolar energy in the treatment of benign prostatic hyperplasia: a current systematic review of the literature

*Rodrigo Donalisio da Silva, MD,[1] *Luke Bidikov, MD,[1,2] Walker Michaels,[1] Diedra Gustafson, BS,[1] Wilson R. Molina, MD,[1,2] Fernando J. Kim, MD[1,2]

[1]Division of Urology, Denver Health Medical Center, Denver, Colorado, USA

[2]Department of Urology, University of Colorado, Denver, Colorado, USA

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Introduction: *For decades, the monopolar transurethral resection of the prostate has been established as the minimally invasive surgical treatment for patients with benign prostatic hyperplasia (BPH). In recent years, new technologies and devices emerged to reduce the morbidity and improve outcomes for this treatment approach. Bipolar energy introduced the use of saline irrigation and laser technology increased the urological armamentarium to treat BPH. We performed a systematic review of the literature regarding bipolar technology for the treatment of BPH.*

Materials and methods: *A MEDLINE database search using the PRISMA methodology. Selected literature was restricted to articles published in English and published between 2005 and 2015. Articles regarding techniques using bipolar energy were included, while manuscripts that used a different technique, hybrid techniques, or techniques other than bipolar resection, bipolar vaporization, and bipolar enucleation were excluded.*

Results: *The use of bipolar energy in the endoscopic treatment of BPH presented a significant reduction in operative time, perioperative complications, shorter catheterization time, reduced number of blood products transfused, and shorter hospital stay compared to standard techniques. Postoperative outcomes showed that bipolar energy was safe and offered significant outcome improvement when compared to traditional monopolar transurethral resection of the prostate (TURP).*

Conclusion: *The use of bipolar energy in the surgical treatment of patients with BPH is safe and is associated with improvements in perioperative outcomes. Short and mid-term functional outcomes are comparable to standard techniques, but long term functional outcomes need better clinical evaluation.*

Key Words: benign prostatic hyperplasia (BPH), bipolar vaporization of the prostate, bipolar resection of the prostate, bipolar enucleation of the prostate, surgical outcomes

Introduction

Benign prostatic hyperplasia (BPH) has a high prevalence, affecting about 25% of men over 50 years of age and poses a significant problem for older men.[1,2] According to the American Urological Association (AUA) and the European Association of Urology (EAU) guidelines, transurethral resection of the prostate (TURP) is the current standard procedure used to treat men who have failed medical therapy for BPH.[3,4] However, the standard monopolar TURP (M-TURP) is associated with increased intraoperative bleeding and TUR syndrome.

Bipolar resection of the prostate (B-TURP) became popular in the treatment of BPH due to the ability

*Authors gave the same contribution

Address correspondence to Dr. Fernando J. Kim, Division of Urology, Denver Health Medical Center, 777 Bannock Street, Denver, CO 80204 USA

TABLE 1a. **BPVP selected studies and patient baseline data**

Author	Study arms	n	Age (yrs)	Vol (g)	Qmax (mL/s)	IPSS	PVR (mL)	PSA (ng/dL)	QoL
Hon et al[16]		160							
2005	BPVP		68.1	40	12	21	182	-	4.3
	M-TURP		68.1	38	12	21	147	-	4.2
Karaman et al[17]		75							
2005	BPVP		65	51	6	22	-	-	-
	M-TURP		66	50	6	21	-	-	-
Kaya et al[18]		40							
2007	BPVP		67.2	50	6	21	-	-	-
	M-TURP		66	51	6	22	-	-	-
Geavlete et al[2]		510							
2011	BPVP		-	54	7	24	91	2.0	4.3
	B-TURP		-	54	6	24	96	1.9	4.5
	M-TURP		-	55	6	24	88	2.1	4.3
Nuhoglu et al[20]		90							
2011	M-TURP		64.7	52	9	21	95	-	-
	BPVP		65.4	53	8	21	92	-	-
Zhang et al[19]		30							
2012	BPVP		70.9	59	5	25	-	-	5.1
	M-TURP		71.9	70	5	27	-	-	5.1
Geavlete et al[13]		180							
2014	C-BPVP		68.9	51	7	24	113	-	-
	S-BPVP		68.9	52	7	24	74	-	-
	M-TURP		68.9	50	6	24	107	-	-
Falahatkar et al[15]		88							
2015	BPVP		79.8	47	9	26	-	-	-
	B-TURP		69.1	48	8	26	-	-	-
Geavlete et al[14]		320							
2015	BPVP		69.5	122	6	25	152	7.6	4.4
	B-TURP		67.5	127	7	2424	158	8.0	4.3
	BPEP		68.5	123	7	25	134	8.2	4.1
	OP		68.7	129	7	25	142	7.8	4

M-TURP = monopolar TURP; B-TURP = bipolar TURP; BPVP = bipolar plasma vaporization of the prostate; BPEP = bipolar plasmakinetic enucleation of the prostate; OP = open prostatectomy; Vol = volume; Qmax = maximum urinary flow rate; IPSS = International Prostate Symptoms Score; PVR = post void residual; PSA = prostate-specific antigen; QoL = quality of life; - signifies that information is not available

to treat patients receiving anticoagulation therapy, reduced risk of TUR syndrome (due to the ability to use sterile saline as irrigant), improvements in hemostatic properties reducing intraoperative and perioperative morbidity, and a shorter learning curve.[2,5-9]

Current techniques that use bipolar energy are bipolar vaporization of the prostate (BPVP), B-TURP, and bipolar endoscopic enucleation (BPEP).[10,11] The B-TURP surgical technique is similar to conventional M-TURP but differs in the energy used to perform the procedure and the use of saline as irrigant. In BPVP, bipolar energy is applied to the tissue using a "button-type" electrode that vaporizes the prostatic tissue without the need to remove prostatic fragments. As an alternative to open prostatectomy (OP), transurethral endoscopic resection of the adenoma is performed using bipolar energy in BPEP in large prostates.

TABLE 1b. **BPVP perioperative outcomes**

Author	Study arms	OR time (minutes)	Cath. time (days)	Hospital stay (days)	Trans. (%)	Hb drop (ng/dL)	Cap. perf. (%)	EBL (mL)
Hon et al[16]	BPVP	29	-	3.4*	5*	1.4*	-	190
2005	M-TURP	33	-	3.0*	0*	0.8*	-	183
Karaman et al[17]	BPVP	55*	3*	-	5.3*	-	-	-
2005	M-TURP	40*	1.5*	-	0*	-	-	-
Kaya et al[18]	BPVP	-	-	-	-	-	-	-
2007	M-TURP	-	-	-	-	-	-	-
Geavlete et al[2]	BPVP	40*	1*	1.9*	1.2*	0.5*	1.2*	-
2011	B-TURP	52*	2*	3.1*	1.8*	1.2*	7.1*	-
	M-TURP	56*	3*	4.2*	6.5*	1.6*	9.4*	-
Nuhoglu et al[20]	M-TURP	53	3*	-	2.1	0.9	-	-
2011	BPVP	57	2.2*	-	0	0.7	-	-
Zhang et al[19]	BPVP	39*	4.1*	8.7*	-	0.7*	-	65*
2012	M-TURP	69*	6.8*	11.7*	-	1.7*	-	255*
Geavlete et al[13]	C-BPVP	32*	1*	2.1*	-	0.4*	1.7*	-
2014	S-BPVP	41*	1*	2.2*	-	0.6*	3.3*	-
	M-TURP	50*	3*	8.3*	-	1.4*	10*	-
Falahatkar et al[15]	BPVP	26*	4.1*	1.9*	0	0.5*	-	-
2015	B-TURP	33*	4.8*	2.1*	4.1	1.4*	-	-
Geavlete et al[14]	BPVP	100*	2.2*	3.2*	1.3*	1.7*	-	-
2015	B-TURP	118*	1.3*	2.1*	0*	0.9*	-	-
	BPEP	87*	1.6*	2.5*	1.3*	1.6*	-	-
	OP	79*	5.4*	6.7*	7.5*	3.1*	-	-

OR time = operating time; cath. time = catheterization time; trans = transfusion; Hb = hemoglobin; cap. perf. = capsular perforation; EBL = estimated blood loss; * = significant ($p < 0.05$)

We conducted a systematic review of randomized clinical trials (RCTs) and large retrospective series of BPVP available in MEDLINE database. We aim to summarize the outcomes and safety of the bipolar energy procedures for the treatment of BPH.

Materials and methods

After a systematic review of the MEDLINE database analysis was performed by the PRISMA methodology.[12] Selected literature was restricted to articles published in English and published between 2005 and 2015. The reference lists all included studies and were scanned for additional pertinent articles. Two authors reviewed all of the obtained abstracts to identify potential articles for the review, and the full manuscript was reviewed and included if both authors achieved consensus. If consensus was not achieved, a third author decided if the publication should be included in the review. Articles regarding techniques using bipolar energy (resection, vaporization, and enucleation) were included, while manuscripts that used hybrid techniques or other techniques were excluded. Also, updated series were excluded.

Results

Bipolar plasma vaporization of the prostate

A total of nine prospective randomized trials that compared BPVP with other techniques were included in the study.[2,13-20]

BPVP selected studies and patient baseline data, Table 1a

Baseline patient characteristics between groups were similar in all included studies and evaluated age, International Prostate Symptoms Score (IPSS), prostate

TABLE 1c. **BPVP postoperative complications**

Author	Study arms	AUR (%)	Clot retention (%)	UTI (%)	UI (%)	Dysuria (%)	BNS (%)	US (%)	Re-interv (%)	TUR syndrome (%)
Hon et al[16]	BPVP	-	-	-	-	-	2.7	1.4	-	-
2005	M-TURP	-	-	-	-	-	1.3	0	-	-
Karaman et al[17]	BPVP	-	-	-	-	-	8	5	-	0
2005	M-TURP	-	-	-	-	-	5	5	-	0
Kaya et al[18]	BPVP	-	-	-	0	-	0	4	12.0*	-
2007	M-TURP	-	-	-	0	-	0	6.7	6.7*	-
Geavlete et al[2]	BPVP	1.8*	0.6*	2.4	0.6	11.2	0.6*	4.7	3.5*	0*
2011	B-TURP	5.9*	1.2*	2.9	1.2	10.6	3.5*	6.5	9.4*	0*
	M-TURP	7.1*	4.1*	3.5	2.4	10.6	4.1*	5.3	8.8*	1.8*
Nuhoglu et al[20]	M-TURP	0	-	-	0	-	-	2.1	0	0
2011	BPVP	4.7	-	-	0	-	-	2.3	0	0
Zhang et al[19]	BPVP	-	-	-	-	-	-	-	-	-
2012	M-TURP	-	-	-	-	-	-	-	-	-
Geavlete et al[13]	C-BPVP	3.3	-	-	-	-	0	1.8	-	-
2014	S-BPVP	1.7	-	-	-	-	0	3.4	-	-
	M-TURP	6.7	-	-	-	-	1.8	1.8	-	-
Falahatkar et al[15]	BPVP	7.7	0	-	-	-	-	0	2.6	0
2015	B-TURP	0	4.1	-	-	-	-	2	0	0
Geavlete et al[14]	BPVP	2.5	2.3	6.3	1.3	-	2.5	4	-	-
2015	B-TURP	3.5	0	6.3	0	-	2.5	6.8	-	-
	BPEP	1.3	1.3	3.8	0	-	1.3	2.8	-	-
	OP	1.3	3.8	8.8	1.3	-	4	1.3	-	-

AUR = acute urinary retention; UTI = urinary tract infection; UI = urinary incontinence; BNS = bladder neck stenosis; US = urethral stricture; TUR = transuretheral resection syndrome; * = significant ($p < 0.05$)

volume, post void residual (PVR), maximum urinary flow rates (Qmax), urinary retention, and prostate-specific antigen (PSA).

BPVP perioperative outcomes, Table 1b

Operative times were available in eight studies. Three studies found no difference in operative times when BPVP was compared with M-TURP,[13,16,20] while two studies (Geavlete, 2014 and Geavlete, 2011) reported significantly shorter operative time in favor of BPVP when compared to M-TURP.[13,17,19] When comparing B-TURP with BPVP, BPVP demonstrated significantly shorter operative time.[15] Geavlete et al used three different bipolar techniques and OP, demonstrating that OP was faster than the other techniques.[14] When comparing BPVP with B-TURP and M-TURP, BPVP was significantly faster than B-TURP and M-TURP.[2] Seven studies reported postoperative catheterization time.[2,13-15,17,19,20] In all studies, BPVP demonstrated significantly shorter postoperative catheterization time. Length of hospital stay was significantly shorter for BPVP procedures compare to other techniques.[2,13-16,19]

BPVP postoperative complications, Table 1c

Objective postoperative follow up data were available in eight manuscripts.

When bipolar energy was used to perform resection or enucleation, no difference was found in postoperative bladder neck stenosis when compared to BPVP.[14] However, comparing BPVP with M-TURP and OP, patients treated with BPVP revealed significantly less incidence of postoperative bladder neck stenosis and re-hospitalization rates were similar between BPVP and B-TURP.[2,15] The earliest studies (Hon, 2005 and Karaman, 2005) reported statistically higher rates of blood transfusion for patients treated with BPVP. In the included studies after 2011, a shift in BPVP blood transfusion rates is evident and patients treated with BPVP required fewer blood transfusions than other techniques.[2,14-17,20]

TABLE 1d. **BPVP functional outcomes**

Author	Study arms	Follow up (mo.)	IPSS	PVR (mL)	Qmax (mL/s)	PSA (ng/dL)	QoL	Prostate volume (g)
Hon et al[16]		8.5						
2005	BPVP		6.9	69	24	-	1.5	-
	M-TURP		7.7	64	26	-	1.7	-
Karaman et al[17]		12						
2005	BPVP		12*	-	15	-	-	-
	M-TURP		7*	-	16	-	-	-
Kaya et al[18]		36						
2007	BPVP		7.6*	-	14*	-	-	-
	M-TURP		5.7*	-	22*	-	-	-
Geavlete et al[12]		18						
2011	BPVP		5*	29	24*	0.9	1	16
	B-TURP		7.9*	31	21*	0.9	1.3	19
	M-TURP		8.3*	33	20*	0.9	1.5	18
Nuhoglu et al[20]		12						
2011	M-TURP		6.2	54	18	-	-	21
	BPVP		6.4	62	18	-	-	25
Zhang et al[19]		-						
2012	BPVP		4.2*	-	16*	-	1.5*	-
	M-TURP		9.3*	-	13*	-	2.6*	-
Geavlete et al[13]		6						
2014	C-BPVP		4.2*	23	24*	0.5	-	14
	S-BPVP		4.4*	21	24*	0.5	-	15
	M-TURP		7.5*	21	21*	0.5	-	16
Falahatkar et al[15]		3						
2015	BPVP		2.6*	-	23*	-	-	-
	B-TURP		5.5*	-	21*	-	-	-
Geavlete et al[14]		12						
2015	BPVP		4.4	28	24*	2.0*	0.9	-
	B-TURP		4.5	25	23*	3.1*	0.8	-
	BPEP		4.2	20	26*	0.7*	0.9	-
	OP		3.9	24	25*	0.7*	1.1	-

IPSS = International Prostate Symptoms Score; PVR = post void residual; Qmax = maximum urinary flow rate; PSA = prostate specific antigen; QoL = quality of life; * = significant ($p < 0.05$)

Conversely, Geavlete et al reported significantly lower re-hospitalization rates for patients treated with BPVP when compared to B-TURP and M-TURP.[2]

BPVP functional outcomes, Table 1d

The postoperative follow up time ranged from 3 to 36 months.[2,14] The IPSS and Qmax values were reported in all studies. All studies reported significant improvements in IPSS compared to the preoperative baseline. When compared to M-TURP, the postoperative IPSS for patients treated with BPVP was statistically lower (improved) in three studies.[2,17-19] Two trials (Nuhoglu, 2011 and Hon, 2005) reported similar postoperative IPSS values between BPVP and M-TURP.[16,20] Two trials (Karaman, 2005 and Kaya, 2007) reported significantly higher postoperative IPSS scores in patients treated with BPVP when compared to M-TURP; however, both groups presented with mild prostate symptoms.[17,18] Geavlete's 2015 study was the only one that compared all three bipolar energy techniques to OP and reported similar postoperative IPSSs for all groups.[14]

Postoperative Qmax improved in all studies when compared to preoperative values. When compared to M-TURP, Qmax values were not statistically significant

TABLE 2a. **BPEP selected studies and patient baseline data**

Author	Study arms	n	Age (yrs)	Vol (g)	Qmax (mL/s)	IPSS	PVR (mL)	PSA (ng/dL)	QoL
Neill et al[21]		40							
2006	HoLEP		69	57	7	26	125	5.3	-
	BPEP		67	51	8	24	114	4.9	-
Zhao et al[1]		202							
2010	BPEP		67	69	9	23	92	2.2	4.5
	M-TURP		68	68	3	22	97	2.3	4.8
Geavlete et al[23]		140							
2013	BPEP		70	133	6	25	164	8.5	4.7
	OP		-	130	6	26	168	8.4	4.6
Ou et al[26]		100							
2013	BPEP		70	132	6	23	90	5.9	4.1
	OP		72	140	5	25	81	5.6	4.3
Rao et al[24]		83							
2013	BPEP		67	116	6	25	83	4.8	5.2
	OP		66	110	6	25	81	4.5	5.1
Xu et al[27]		80							
2013	DLEP		-	69	8	24	53	2.8	4.4
	BPEP		-	66	8	24	67	2.7	4.6
Zhu et al[22]		80							
2013	BPEP		64	114	5	25	210	3	4.2
	B-TURP		65	109	4	25	290	2.8	3.8
Luo et al[25]		310							
2014	BPEP		70	62	8	23	-	-	-
	B-TURP		70	62	8	22	-	-	-

M-TURP = monopolar TURP; B-TURP = bipolar TURP; HoLEP = holmium laser enucleation of the prostate; BPEP = bipolar plasmakinetic enucleation of the prostate; DLEP = diode laser enucleation of the prostate; OP = open prostatectomy; Vol = volume; Qmax = maximum urinary flow rate; IPSS = International Prostate Symptoms Score; PVR = post void residual; PSA = prostate-specific antigen; QoL = quality of life; - signifies that information is not available

except for Geavlete's 2011 study that demonstrated higher Qmax values with B-TURP.[2] Although open prostatectomy has shown statistically higher Qmax when compared to BPVP, BPEP, and B-TURP, the values are within normal rates and it may not provide any significant clinical difference.[14] When compared with two resection techniques (monopolar and bipolar), BPVP presented statistically higher Qmax values.[2]

Bipolar plasma enucleation of the prostate

Eight randomized clinical trials evaluated BPEP.[1,21-27]

BPEP selected studies and patient baseline data, Table 2a

BPEP was compared to open prostatectomy in three studies.[23,24,26] Another two trials compared BPEP with laser enucleation.[21,27]

BPEP was prospectively compared to B-TURP in two trials[1,22,25] and M-TURP in one study.[1] The baseline patient characteristics were not significantly different in all included studies, Table 2a. All studies excluded patients with acute urinaryr etention.

BPEP perioperative outcomes, Table 2b

Operative time was similar among BPEP, M-TURP, OP, and B-TURP.[1,22-26] The two trials (Neill, 2006 and Xu, 2013) that compared BPEP with laser enucleation found significantly shorter operative times when using laser enucleation.[21,27]

Five clinical trials reported significantly shorter perioperative catheterization periods when BPEP was performed.[1,19,22,23,26] Only Xu's 2013 trial reported a significant increase in catheterization time for BPEP when compared to laser enucleation.[27]

TABLE 2b. **BPEP perioperative outcomes**

Author	Study arms	OR time (minutes)	Cath. time (days)	Hospital stay (days)	Trans. (n)	Hb drop (ng/dL)	Cap. perf. (%)	EBL (n)
Neill et al[21]	HoLEP	44*	1	1	1	-	-	-
2006	BPEP	61*	1	1	7	-	-	-
Zhao et al[1]	BPEP	63	2*	4*	0	0.03*	-	-
2010	M-TURP	55	3*	6*	0	0.07*	-	-
Geavlete et al[23]	BPEP	91	2*	2*	1	1.7*	-	-
2013	OP	88	6*	7*	6	3.1*	-	-
Ou et al[26]	BPEP	100	4*	6*	3	1.2*	-	-
2013	OP	106	8*	9*	3	2*	-	-
Rao et al[24]	BPEP	111	3*	5*	0	1.0*	-	-
2013	OP	110	6*	9*	4	1.5*	-	-
Xu et al[27]	DLEP	34*	1*	5	0	0.93*	5	-
2013	BPEP	50*	2*	5	0	1.6*	2.5	-
Zhu et al[22]	BPEP	94	2*	3*	0	0.9*	-	-
2013	B-TURP	89	3*	4*	1	1.7*	-	-
Luo et al[25]	BPEP	63	4	6	-	-	-	121*
2014	B-TURP	60	4	6	-	-	-	142*

OR time = operating time, Cath. time = catheterization time, Trans. = transfusion, Hb = hemoglobin, Cap. perf. = capsular perferation, EBL = estimated blood loss, * = significant ($p < 0.05$)

TABLE 2c. **BPEP postoperative complications**

Author	Study arms	AUR (%)	Clot retention (%)	UTI (%)	UI (%)	Dysuria (%)	BNS (%)	US (%)	Re-interv (%)	TUR syndrome (%)
Neill et al[21]	HoLEP	-	-	5	5	-	-	1	0	-
2006	BPEP	-	-	5	10	-	-	1	1	-
Zhao et al[1]	BPEP	-	-	2.2	2.2	-	1	0	0	-
2010	M-TURP	-	-	3.4	2.2	-	0	3	2	-
Geavlete et al[23]	BPEP	1.4	-	2.9	1.6	-	1	2	-	-
2013	OP	8.6	-	5.7	1.6	-	1	2	-	-
Rao et al[24]	BPEP	2.3	-	7	4.7	-	0	1	-	0
2013	OP	7.5	-	12	10	-	2	3	-	0
Ou et al[26]	BPEP	4.3	0	6.4	2.1	-	-	1	1	-
2013	OP	2.2	2.2	6.7	2.2	-	-	0	0	-
Xu et al[27]	DLEP	-	-	-	7.5	0	-	0	-	-
2013	BPEP	-	-	-	10	0	-	0	-	-
Zhu et al[22]	BPEP	-	-	2.5	0	-	0	1	-	-
2013	B-TURP	-	-	2.5	0	-	1	1	-	-
Luo et al[25]	BPEP	2.6	-	5.9	17*	2.6	1	5	-	-
2014	B-TURP	3.2	-	5.2	5.8*	3.2	2	4	-	-

AUR = acute urinary retention; UTI = urinary tract infection; UI = urinary incontinence; BNS = bladder neck stenosis; US = urethral stricture; TUR = transuretheral resection syndrome; * = significant ($p < 0.05$)

TABLE 2d. **BPEP functional outcomes**

Author	Study arms	Follow up (mo.)	IPSS	PVR (mL)	Qmax (mL/s)	PSA (ng/dL)	QoL	Prostate volume (g)
Neill et al[21]		12						
2006	HoLEP		7.6	-	19	2	-	-
	BPEP		7.3	-	22	2.2	-	-
Zhao et al[1]		36						
2010	BPEP		2.4*	5	29*	0.6	0.6*	21*
	M-TURP		4.3*	5	25*	0.7	1.6*	26*
Geavlete et al[23]		12						
2013	BPEP		4.1	1	25	0.8	1	21
	OP		4.3	0.2	25	0.8	1.2	22
Ou et al[26]		12						
2013	BPEP		5.6	28	16	-	1.3	-
	OP		5.8	25	17	-	1.3	-
Rao et al[24]		12						
2013	BPEP		3.4	5	27	0.6	1.4	-
	OP		3.5	6	26	0.6	1.6	-
Xu et al[27]		12						
2013	DLEP		4.9	1	23	1.1	1.2	27
	BPEP		5.3	2	23	1.1	1.2	26
Zhu et al[22]		60						
2013	BPEP		3.3*	4*	27*	-	1	-
	B-TURP		4.9*	15*	22*	-	1	-
Luo et al[25]		24						
2014	BPEP		3.4	-	25	-	1	-
	B-TURP		3.1	-	25	-	1.2	-

IPSS = International Prostate Symptoms Score; PVR = post void residual; Qmax = maximum urinary flow rate; PSA = prostate-specific antigen; QoL = quality of life; * = significant ($p < 0.05$)

Zhao's 2010 trial comparing M-TURP to BPEP showed significantly shorter hospital stays for the enucleation group.[1] Of the two trials comparing BPEP to B-TURP, Zhu's 2013 study reported shorter hospital stays for BPEP[22,26] while one reported no difference.[25] A shorter hospital stay was found in BPEP when compared to OP.[23,24,26] Blood transfusion rates reported were statistically similar, Table 2b.

BPEP postoperative complications, Table 2c

Objective postoperative data were available in all eight studies. Urinary tract infection (UTI) and urethral stricture were reported in all studies and were found to have similar rates. Luo et al was the only study to report that enucleation had a significantly higher rate (17% versus 5.8%) of urinary incontinence than B-TURP.[25] Urinary incontinence rates may vary due to the subjective and unstandardized definition of the issue.

Not all trials reported all complications, but the trials which did found no significant differences for BPEP except for urinary incontinence reported by Luo et.al.[25] Variations for BPEP included an increase in early irritative symptoms when compared to laser enucleation,[27] and a decreased rate of hematuria when compared to OP.[23]

BPEP functional outcomes, Table 2d

Follow up ranged from 12 to 60 months. Two studies found significantly different Qmax and IPSS results, one comparing BPEP against M-TURP[1] and another comparing BPEP against B-TURP.[22] In both studies, lower IPSS scores and higher Qmax scores were reported when enucleation was used.

Only one study reported significantly lower PVR volumes for BPEP when compared to B-TURP,[22] and lower QoL values and postoperative prostate

TABLE 3a. **B-TURP selected studies and patient baseline data**

Author	Study arms	n	Age (yrs)	Vol (g)	Qmax (mL/s)	IPSS	PVR (mL)	PSA (ng/dL)	QoL
De Sio et al[31] 2006	M-TURP	79	61	48	6	24	75	2.4	3.9
	B-TURP		59	52	7	24	80	2.1	4.2
Erturhan et al[33] 2007	M-TURP	240	67	42	9	24	135	-	3.0
	B-TURP		69	43	11	23	114	-	2.0
Ho et al[35] 2007	M-TURP	100	67	55	7	25	-	2.2	-
	B-TURP		67	57	7	23	-	2.8	-
Autorino et al[28] 2009	M-TURP	70	61	48	6	24	75	2.1	3.9
	B-TURP		59	52	7	24	80	2.4	4.2
Chen et al[29] 2010	B-TURP	100	70	60	7	23	73	1.8	-
	M-TURP		71	59	8	22	80	2.0	-
Engeler et al[32] 2010	B-TURP	208	70	50	8	18	186	4.2	3.0
	M-TURP		69	49	9	18	195	4.3	3.6
Geavlete et al[2] 2011	BPVP	510	67	54	7	24	91	2.0	4.3
	B-TURP		-	54	6	24	96	1.9	4.5
	M-TURP		-	55	6	24	88	2.1	4.3
Chen et al[30] 2013	HoLEP	280	74	57	7	23	128	2.2	4.5
	B-TURP		72	60	7	24	131	2.4	4.6
Giulianelli et al[34] 2013	B-TURP	160	63	48	9	22	243	2.2	3.3
	M-TURP		64	50	7	23	187	2.8	3.0
Kumar et al[37] 2013	M-TURP	156	64	52	7	21	139	2.6	3.7
	B-TURP		62	50	7	20	148	2.9	3.6
	BPVP		65	53	7	20	143	2.4	3.6
Mamoulakis et al[38] 2013	M-TURP	255	68	64	-	-	-	5.3	-
	B-TURP		69	64	-	-	-	5.1	-
Yang et al[39] 2013	B-TURP	158	61	69	9	23	72	2.4	4.9
	ThuLEP		62	72	9	23	79	2.5	3.9
Komura et al[36] 2014	M-TURP	125	68	53	7	22	47	6.3	5.2
	B-TURP		70	51	6	24	44	4.6	5.2
Luo et al[25] 2014	BPEP	310	70	62	8	23	-	-	4.9
	B-TURP		70	62	8	22	-	-	4.9

M-TURP = monopolar TURP; B-TURP = bipolar TURP; HoLEP = holmium laser enucleation of the prostate; BPVP = bipolar plasma vaporization of the prostate; BPEP = bipolar plasmakinetic enucleation of the prostate; ThuLEP = thulium laser enucleation of the prostate; Vol = volume of prostate; Qmax = maximum urinary flow rate; IPSS = International Prostate Symptoms Score; PVR = post void residual; PSA = prostate-specific antigen, QoL = quality of life; - signifies that information was not available

volumes for BPEP when compared to M-TURP.[1] No other significantly different functional outcomes were reported.

Bipolar transurethral resection of the prostate

A total of 14 prospective randomized trials compared B-TURP with other techniques and were included in the study.[2,25,28-39]

B-TURP selected studies and patient baseline data, Table 3a

Nine trials compared B-TURP and M-TURP,[29-35,40] two trials compared B-TURP and laser resection,[30,39] one trial compared B-TURP to plasma enucleation,[25] and two trials had three arms: M-TURP, B-TURP, and plasma vaporization.[2,37] There was no statistically significant difference in preoperative patient baseline characteristics.

TABLE 3b. **B-TURP perioperative outcomes**

Author	Study arms	OR time (minutes)	Cath. time (days)	Hospital stay (days)	Trans. (n)	Hb drop (ng/dL)	Cap. perf. (%)	EBL (mL)
De Sio et al[31]	M-TURP	53	4	4.5*	0	0.9	-	-
2006	B-TURP	49	3	3.3*	1	0.6	-	-
Erturhan et al[33]	M-TURP	57*	5	5*	7*	-	5.8*	7*
2007	B-TURP	36*	3	3*	1*	-	1.7*	1*
Ho et al[35]	M-TURP	58	-	-	1	1.8	-	-
2007	B-TURP	50	-	-	1	1.2	-	-
Autorino et al[28]	M-TURP	53	1	-	-	1	-	-
2009	B-TURP	49	2	-	-	0.8	-	-
Chen et al[29]	B-TURP	69	-	-	1	1.1*	20	-
2010	M-TURP	60	-	-	3	1.6*	39	-
Engeler et al[32]	B-TURP	50*	3	8.1	0	14	-	-
2010	M-TURP	41*	3	6.7	0	14	-	-
Geavlete et al[2]	BPVP	40*	1	1.9*	2*	0.5*	1.2*	3*
2011	B-TURP	52*	2	3.1*	3*	1.2*	7.1*	14*
	M-TURP	56*	3	4.2*	11*	1.6*	9.4*	23*
Chen et al[30]	HoLEP	87*	3	3.6*	0	1.1*	-	-
2013	B-TURP	60*	4	4.4*	1	1.3*	-	-
Giulianelli et al[34]	B-TURP	58	1	2	0	1.2	-	-
2013	M-TURP	59	2	3	3	4.1	-	-
Kumar et al[37]	M-TURP	46*	1.5*	-	7*	1.5*	-	-
2013	B-TURP	46*	1.5*	-	1*	1.5*	-	-
	BPVP	60*	1*	-	0*	0.7*	-	-
Mamoulakis et al[38]	M-TURP	52	3	3.5	-	-	-	30
2013	B-TURP	52	3	3.5	-	-	-	30
Yang et al[39]	B-TURP	47*	3.5*	4.6	0	0.3*	-	-
2013	ThuLEP	65*	2*	2.5	0	0.2*	-	-
Komura et al[36]	M-TURP	68*	1.5*	3.4	4	1.5	-	-
2014	B-TURP	80*	1*	2.5	1	1.5	-	-
Luo et al[25]	BPEP	63	4	5.5	0	-	-	-
2014	B-TURP	60	4	5.5	0	-	-	-

OR time = operating time; Cath. time = catheterization time; Trans. = transfusion; Hb = hemoglobin; Cap. perf. = capsular perforation; EBL = estimated blood loss; * = significant ($p < 0.05$)

B-TURP perioperative outcomes, Table 3b

Of the trials comparing B-TURP to M-TURP, six found no significant difference[28,29,31,34,35,38] two (Engeler, 2010 and Komura, 2014) found that M-TURP had a shorter operating time,[32,36] and one (Erturhan, 2007) found that B-TURP had a shorter operating time.[33] Luo et al found no significance in operating time when comparing B-TURP to plasma enucleation.[25] Of the two studies (Geavlete, 2011 and Kumar, 2013) comparing B-TURP to M-TURP and vaporization, both found that B-TURP had a longer operating time than M-TURP.[2,37] Both laser/B-TURP trials found that B-TURP was significantly faster.[30,39]

Patients treated with B-TURP experienced significantly shorter catheterization time as well as significantly shorter hospital stay,[31,33,36] while four did not report a significant difference.[28,32,34,38] Both laser/B-TURP comparisons showed laser resection to be significantly faster than B-TURP.[30,39] Luo et al's study comparing B-TURP to plasma enucleation and

TABLE 3c. **B-TURP postoperative complications**

Author	Study arms	AUR (%)	Clot retention	UTI (%)	UI (%)	Dysuria (%)	BNS (%)	US (%)	Re-interv (%)	TUR syndrome (%)
De Sio et al[31]	M-TURP	0	11.4	-	-	-	3.0	-	2.9	0
2006	B-TURP	0	5.7	-	-	-	2.9	-	2.9	0
Erturhan et al[33]	M-TURP	-	14.2*	-	0	15.8*	-	1.7	4.2*	1.7
2007	B-TURP	-	1.7*	-	0	7.5*	-	1.7	0*	0
Ho et al[35]	M-TURP	-	4.2	4.2	-	-	-	2.0	-	4.2*
2007	B-TURP	-	5.8	3.8	-	-	-	5.8	-	0*
Autorino et al[28]	M-TURP	-	-	-	-	-	3.2	6.4	9.6	-
2009	B-TURP	-	-	-	-	-	3.1	3.1	6.2	-
Chen et al[29]	B-TURP	0	-	-	16	-	2.0	4.0	6.0	0
2010	M-TURP	4	-	-	20	-	4.0	6.0	10.0	0
Engeler et al[32]	B-TURP	-	-	-	-	-	-	0	0.9	0
2010	M-TURP	-	-	-	-	-	-	1.0	0	1
Geavlete et al[2]	BPVP	1.8*	1*	2.4	0.6	11.2	0.6*	4.7	3.5*	0*
2011	B-TURP	5.9*	2*	2.9	1.2	10.6	3.5*	6.5	9.4*	0*
	M-TURP	7.1*	7*	3.5	2.4	10.6	4.1*	5.3	8.8*	1.8*
Chen et al[30]	HoLEP	0	-	-	22.4	-	-	-	1.7	-
2013	B-TURP	3.8	-	-	7.7	-	-	-	3.8	-
Giulianelli et al[34]	B-TURP	0	1.3	0	0	-	1.3	-	-	0
2013	M-TURP	11.3	5.0	2.5	0	-	6.5	-	-	2.5
Kumar et al[37]	M-TURP	6.7	10.0*	8.3	-	3.3	0	1.7	-	1.7
2013	B-TURP	5.3	3.5*	10.5	-	1.8	1.8	0	-	0
	BPVP	8.6	0*	6.9	-	8.6	1.7	1.7	-	0
Mamoulakis et al[38]	M-TURP	-	-	-	-	-	1.9	9.3	4.6	-
2013	B-TURP	-	-	-	-	-	6.6	8.2	4.1	-
Yang et al[39]	B-TURP	-	3.8	-	-	-	0	0	-	0
2013	ThuLEP	-	1.2	-	-	-	0	0	-	0
Komura et al[36]	M-TURP	3.2	11.3	14.5	0	-	-	-	-	0
2014	B-TURP	3.2	1.6	4.8	0	-	-	-	-	0
Luo et al[25]	BPEP	2.6	-	5.9	17.1*	2.6	0.7	3.6	-	0
2014	B-TURP	3.2	-	5.2	5.8*	3.2	1.4	2.9	-	0

AUR = acute urinary retention; UTI = urinary tract infection; UI = urinary incontinence; TUR = transuretheral resection syndrome; * = significant ($p < 0.05$)

did not find a significant difference between the two methods.[25] The B-TURP/M-TURP/vaporization comparisons showed vaporization to be significantly faster.[2,37]

B-TURP postoperative complications, Table 3c

Postoperative acute urinary retention (necessitating catheterization) was found to be significantly higher for B-TURP compared to vaporization in a B-TURP/M-TURP/vaporization comparison.[2] For the three other B-TURP/M-TURP trials,[29,31,36] Chen's 2013 trial comparing B-TURP to laser resection[30] and Luo's 2014 trial comparing bipolar enucleation to resection,[25] no statistical difference was found.

All but three articles found no significant difference between groups for urethral stricture.[2,25,28,29,32,33,35,37-39]

Only Geavlete's 2011 study[2] found statistically different rates of bladder neck stenosis; vaporization had lower bladder neck stenosis rates when compared to B-TURP.

TABLE 3d. **B-TURP functional outcomes**

Author	Study arms	Follow up (mo.)	IPSS	PVR (mL)	Qmax (mL/s)	PSA (ng/dL)	QoL	Prostate volume (g)
De Sio et al[31]		12						
2006	M-TURP		-	-	-	-	-	-
	B-TURP		-	-	-	-	-	-
Erturhan et al[33]		12						
2007	M-TURP		4	25	19	-	2	-
	B-TURP		4	15	20	-	2	-
Ho et al[35]		12						
2007	M-TURP		-	-	-	-	-	-
	B-TURP		-	-	-	-	-	-
Autorino et al[28]		48						
2009	M-TURP		6	45	21	-	1.4	37
	B-TURP		7	52	20	-	1.3	39
Chen et al[29]		24						
2010	B-TURP		4	-	26	-	-	-
	M-TURP		4	-	25	-	-	-
Engeler et al[32]		12						
2010	B-TURP		14	154	10	-	1.9	-
	M-TURP		11	96	10	-	1.2	-
Geavlete et al[2]		18						
2011	BPVP		5*	29	24*	0.9	1	16
	B-TURP		7.9*	31	21*	0.9	1.3	19
	M-TURP		8.3*	33	20*	0.9	1.5	18
Chen et al[30]		24						
2013	HoLEP		5	22	24	1.0*	1.0	30*
	B-TURP		5	23	23	1.4*	1.0	35*
Giulianelli et al[34]		36						
2013	B-TURP		2	0	23	0.9	0.5	-
	M-TURP		4	0	20	1.5	1	-
Kumar et al[37]		12						
2013	M-TURP		7	27	19	-	1.6	25
	B-TURP		7	31	20	-	1.7	25
	BPVP		7	31	20	-	1.6	25
Mamoulakis et al[38]		36						
2013	M-TURP		-	-	-	-	-	-
	B-TURP		-	-	-	-	-	-
Yang et al[39]		18						
2013	B-TURP		5	31	23	-	1.2	-
	ThuLEP		6	31	23	-	1.2	-
Komura et al[36]		36						
2014	M-TURP		4	7	19	6.7	1.7	-
	B-TURP		5	10	17	5.8	2.3	-
Luo et al[25]		24						
2014	BPEP		3	-	25	-	1.0	-
	B-TURP		3	-	25	-	1.2	-

IPSS = International Prostate Symptoms Score; PVR = post void residual; Qmax = maximum urinary flow rate; PSA = prostate-specific antigen; QoL = quality of life; * = significant ($p < 0.05$)

Only two studies (Geavlete, 2011 and Ho, 2007) found that M-TURP had a significantly higher TUR syndrome rate than B-TURP[2,35] while all others showed no significant differences.[28,30,38]

B-TURP functional outcomes, Table 3d

Postoperative follow up ranged from 12 months to 48 months. Only Geavlete's 2011 trial[2] showed significantly higher IPSS and lower Qmax values for B-TURP and was the only study that found significance. Chen's 2013 study showed significantly higher PSA values and prostate volumes for B-TURP.[30] Yang's 2013 study found no statistically different functional outcomes between ThuLEP and B-TURP.

Discussion

Monopolar TURP has remained the gold standard surgical treatment of symptomatic BPH for patients who failed medical treatment. However, M-TURP may cause TUR syndrome and increased bleeding, especially in anticoagulated patients, increasing morbidity and cost.

Conversely, bipolar TURP has emerged, offering advantages such as the use of sterile saline irrigant and better coagulation properties when compared to M-TURP.[41]

The improvement in coagulation properties of B-TURP is credited to the greater mean depth of coagulation which is larger than the maximum diameter of a microvessel.[41,42] The reduced bleeding caused by better coagulation provides the surgeon a clear visual field, resulting in decreased operative time and fewer intraoperative complications. BPVP demonstrated superior outcomes in all of the following areas: perioperative period, postoperative complications, and functional outcomes.[2,13-18,20] Costs were not directly analyzed among the selected clinical trials; however, the reduced catheterization period, hospital stay, need for blood transfusions, volume of postoperative irrigation fluids, and intraoperative complications can be associated with a more cost-effective procedure when using BPVP.

Functional outcomes were mainly measured by an IPSS questionnaire, PVR, and Qmax. BPVP was associated with significant improvements in IPSS and Qmax when compared to other techniques.[2,13-15,18,19] Postoperative PVR volumes improved in all techniques and did not demonstrate statistically differences among techniques when compared to BPVP.

TUR syndrome was reduced after the introduction of bipolar energy.[41] A recent meta-analysis collected data of 31 clinical trials comparing M-TURP to B-TURP and showed significant differences between M-TURP and B-TURP as well as significant improvements in safety, occurrence of TUR syndrome, and clot retention.[41]

The bipolar energy device allows the surgeon to choose among different techniques in the management of BPH. Patients utilizing coagulation modifying drugs (anticoagulants, Aspirin, Clopidogrel, Ticagrelor and others) can benefit from vaporization techniques using bipolar energy.[43] The surgeon can also resect prostatic tissue using bipolar energy with a loop electrode with better perioperative results and comparable functional outcomes when compared to standard M-TURP.[28,29,31,35,36,38] For large prostates (larger than 100 g), OP still remains a good surgical option; however, it is associated with increased bleeding, longer hospital stay, and the need for surgical incision when compared to BPEP.[23] Functional outcomes of BPEP are comparable to OP, although the decrease in morbidity when using BPEP adds to the overall clinical advantage of BPEP for the patient.[23]

There are a large number of studies available which evaluate safety and outcomes of M-TURP for prostate sizes of 30 g-80 g. However, M-TURP is associated with higher morbidity when compared to other techniques.[44] B-TURP has short and mid-term results that are comparable to M-TURP. However, B-TURP has a more favorable perioperative outcomes and safety profile when compared to M-TURP.[45]

The number of available clinical trials evaluating BPVP is increasing. When compared to M-TURP and B-TURP, BPVP results show that this procedure is safe, and it has comparable mid-term postoperative results.[1,2,14,16-18,46]

Bipolar enucleation is the newest of the bipolar modalities introduced in 2006.[21] B-TURP and BPVP are also performed in large prostates without major complications.[14,47] An alternative to resection and vaporization techniques for larger prostates is enucleating the adenoma tissue using bipolar energy. When compared to OP, BPEP has less operative time, irrigation, catheterization time, and hospital stay.[23,24] BPEP has similar functional outcomes in clinical trials when compared to OP.[23,24] The differences between the bipolar resection (loop) versus vaporization (button-type electrode) and the varying techniques of the procedure (i.e. depth of enucleation) complicates and it challenges a systemic comparison and review. Luo et al compared enucleation to B-TURP; when the data was split into cohorts based on prostate size, the results showed a significantly shorter operative time for enucleation compared to B-TURP in large prostates (and no significant difference in aggregate).[25] Future studies are needed to confirm a reduction in operative time for large prostates.

Medical professionals are always concerned about the costs associated with new technology. Studies are regularly published demonstrating the benefits of new technologies such as laser and bipolar energy in the surgical treatment of BPH, though it is not yet considered the gold standard procedure nor is it economically feasible for all hospitals. Urological practices that are unable to offer bipolar and other new technologies may follow the current guidelines which still consider M-TURP the gold standard procedure to treat patients with BPH who have failed medical therapy.[3,44]

The use of bipolar energy for the surgical treatment of BPH seems to improve safety and perioperative outcomes when compared to standard techniques (M-TURP and OP). This emerging technology seems to improve clinical benefits for patients that require surgical treatment of BPH, especially due to the coagulative properties associated with bipolar energy.

Future research in the surgical treatment of BPH

The increase in life span will have a strong impact in health care systems regarding age-associated diseases including BPH. Although medical therapy has evolved, the optimal minimally invasive therapy for BPH has not been defined yet.

Today, the treatment of BPH is focused on symptomatic BPH therapy and does not address prevention or permanent cure. Surgical treatment is still a good option to treat patients that failed medical therapy, but aging patients can develop other comorbidities, increasing the surgical risks.

With the advent of bipolar energy and lasers, the incidence of TUR syndrome has almost been eliminated. Well-designed clinical trials evaluating new technologies with validated and standard data collection is sought after.

Finally, the importance of costs, safety, and long term functional outcomes must be addressed with future studies.

Conclusion

The use of bipolar energy in the surgical treatment of patients with BPH is safe and is associated with improvements in perioperative outcomes. Short and mid-term functional outcomes are comparable to standard techniques, but long term functional outcomes need further clinical evaluation.

Disclosure

All authors have no disclosure. □

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