

Impact of bipolar versus holmium laser enucleation on sexual function in men with prostate > 60 g: a prospective two-center randomized controlled trial

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Abstract

Background

Enucleation of the prostate is effective for large glands, but the effect of the energy source on sexual function is uncertain. We compared bipolar enucleation (BipoLEP) and holmium laser enucleation (HoLEP) on erectile and ejaculatory function.

Methods

In a prospective, two-center randomized trial, 80 men with a prostate larger than 60 g were allocated to BipoLEP (n = 40) or HoLEP (n = 40). The primary outcome was the IIEF erectile-function domain at 6 months; secondary outcomes were the other IIEF domains, the IIEF-15 total, and the MSHQ-EjD ejaculatory domains, assessed before surgery and at 3 and 6 months. Between- and within-group comparisons were supported by a two-way mixed ANOVA and by analysis of covariance adjusting for baseline imbalances.

Results

The arms were comparable at baseline apart from serum prolactin and educational level. No IIEF erectile-domain score differed between techniques at any time point, including three months. Both arms improved from baseline to six months, with a significant effect of time and no time-by-technique interaction; the equivalence held after adjustment. Bipolar enucleation was associated with higher MSHQ-EjD ejaculatory frequency, strength, and total score and less bother at six months. Responder rates and de novo erectile dysfunction were similar.

Conclusions

Bipolar and holmium laser enucleation gave comparable erectile recovery over six months, with no short-term advantage for either technique. Bipolar enucleation was associated with somewhat better ejaculatory outcomes. Both procedures are effective options for men with large prostates, and ejaculatory function may be the more useful factor when choosing between them.

Background

Benign prostatic hyperplasia (BPH) is the most common benign tumor in ageing men and a leading cause of lower urinary tract symptoms (LUTS) [1]. Its prevalence rises steeply with age, affecting a large share of men beyond the sixth decade, and the resulting symptom burden drives a substantial number of surgical referrals each year [2]. For decades transurethral resection of the prostate (TURP) was the

reference standard for glands of moderate size, while larger prostates were often managed by open surgery [3].

Anatomical endoscopic enucleation of the prostate has changed this picture. By developing the plane between the adenoma and the surgical capsule, enucleation removes obstructing tissue completely and works across a wide range of prostate volumes, including glands heavier than 80 g that were previously difficult to treat endoscopically [4]. Holmium laser enucleation of the prostate (HoLEP) is the most extensively studied of these procedures and is recommended as a size-independent option in current practice [5]. Bipolar enucleation of the prostate (BipoLEP) applies the same enucleation principle using bipolar plasmakinetic energy in saline, and it offers a lower-cost alternative where laser platforms are not available [6]. Both techniques relieve obstruction well, so attention has shifted to how they affect quality of life, and sexual function is among the outcomes patients value most [5].

Sexual function in men with BPH is complex and involves both erectile and ejaculatory components. LUTS and erectile dysfunction share vascular and neurogenic mechanisms and often occur together, so many men already have reduced sexual function before any operation [7]. Surgery can move sexual function in either direction. Relief of bothersome urinary symptoms may improve overall sexual satisfaction, while work around the prostate and bladder neck can harm the mechanisms that support erection and antegrade ejaculation [8]. Ejaculatory dysfunction, and retrograde ejaculation in particular, is the most frequent sexual side effect after prostate surgery and follows disruption of the bladder neck during tissue removal [9]. Because enucleation removes more tissue and works closer to the bladder neck than resection, its effect on ejaculation is a real clinical concern [5].

Erectile and ejaculatory function are usually measured with validated questionnaires. The International Index of Erectile Function (IIEF) captures erectile function, orgasmic function, sexual desire, intercourse satisfaction, and overall satisfaction [13]. The Male Sexual Health Questionnaire ejaculatory dysfunction short form (MSHQ-EjD) measures the frequency, strength, and volume of ejaculation together with the degree of bother, and it complements the IIEF by covering the domain most often affected by prostate surgery [14]. Using both instruments gives a fuller account of how a procedure affects a man's sexual life.

The evidence comparing enucleation techniques on sexual function is limited and, at times, inconsistent. Systematic reviews suggest that different surgical approaches to LUTS have broadly similar effects on erectile function, yet most primary studies focus on urinary outcomes and report sexual endpoints as secondary measures [8]. Studies that compare laser and bipolar enucleation directly are few, tend to be small, and rarely follow patients with dedicated ejaculatory instruments [15]. It therefore remains unclear whether the energy source or the enucleation technique itself carries any advantage for preserving sexual function, and whether any early difference persists over time. This question matters most for sexually active men who worry about the effect of surgery on their performance.

We conducted a prospective, two-center randomized trial comparing BipoLEP and HoLEP in men with a prostate larger than 60 g. Our aim was to evaluate the effect of each technique on erectile and

ejaculatory function over six months, using the IIEF for erectile-domain outcomes and the MSHQ-EjD for ejaculatory outcomes. By randomizing patients between the two methods and assessing both domains prospectively, we sought to clarify whether the choice of energy affects sexual recovery and to give patients and surgeons better information for shared decisions.

Methods

Study design and participants

This was a prospective, two-center, parallel-group randomized controlled trial with a 1:1 allocation ratio, conducted at two centers in Egypt, a university hospital and a general hospital (center names withheld for double-anonymous peer review). We enrolled and randomized participants between April 2024 and May 2024. Because both procedures depended on the availability of dedicated operating lists and equipment, the allocated operations were performed over the subsequent three months; each participant was then followed for six months from the date of surgery, and the final follow-up assessment was completed in February 2025. Eligible participants were men with lower urinary tract symptoms due to benign prostatic hyperplasia and a prostate volume greater than 60 g who were candidates for surgical treatment. Exclusion criteria were previous prostate or urethral surgery, known or suspected prostate cancer, neurogenic bladder, active urinary tract infection, and inability to complete the questionnaires. All participants gave written informed consent. The study was carried out in accordance with the Declaration of Helsinki and was approved by the institutional research ethics committee of the coordinating center, whose approval covered recruitment at both participating centers (committee name and approval code withheld for double-anonymous peer review). There were no changes to the trial design or to the pre-specified outcomes after the trial commenced. The trial was not registered in a public clinical trials registry.

Sample size

The trial was not formally powered a priori. To characterize the smallest effect the study could detect, a sensitivity analysis was performed using the analyzed sample (39 BipoleP and 40 HoLEP; 79 of 80 randomized participants, 1.3% attrition) and the observed 6-month erectile-function-domain standard deviation of 3.1 points. Using standard power-analysis methods, [11] with 39 and 40 participants per arm at a two-sided significance level of 0.05, the study had approximately 80% power to detect a between-arm difference of 2.0 points on the erectile-function domain, which is the smallest published minimal clinically important difference for this domain, [10] and more than 99% power to detect a 4-point difference. This corresponds to a required 38 participants per arm to detect the 2-point difference, which the enrolled sample of 40 per arm exceeded. Power calculations were performed with the pwr package (version 1.3-0) [12] in R.

Randomization and blinding

Eighty men were randomized in a 1:1 ratio to bipolar enucleation of the prostate (BipoLEP, n = 40) or holmium laser enucleation of the prostate (HoLEP, n = 40). The allocation sequence was generated using computer-generated random numbers, with permuted blocks. Allocation was concealed using sealed, opaque, sequentially numbered envelopes, which were opened only after enrollment. The sequence was generated by an independent statistician who was not involved in patient care, participants were enrolled by the attending urologist at each center, and allocation was assigned by a research nurse independent of the surgical team. Because the two procedures require different equipment, surgeons and participants could not be blinded to the allocated technique; however, the outcome assessors who administered the questionnaires were blinded to treatment allocation, and the questionnaires were self-completed by participants.

Procedures

Both operations followed the standard anatomical enucleation principle, developing the plane between the adenoma and the surgical capsule, followed by transurethral morcellation. BipoLEP was performed with a bipolar plasmakinetic system in saline irrigation at 280 W for cutting and 120 W for coagulation, and HoLEP with a holmium: YAG laser at 100 W (2.0 J at 50 Hz) using a 550 µm end-firing fibre. Morcellation used a mechanical transurethral tissue morcellator. The urethral catheter was removed after 48 h, and patients were discharged after a median hospital stay of 3 days. All procedures were carried out by experienced enucleation surgeons who had each completed at least 50 prior cases.

Outcomes and measurements

The primary outcome was the erectile-function domain of the International Index of Erectile Function (IIEF) at 6 months. Secondary outcomes were the other IIEF domains (orgasmic function, sexual desire, intercourse satisfaction, and overall satisfaction) and the IIEF-15 total score, and the ejaculatory domains of the Male Sexual Health Questionnaire ejaculatory dysfunction short form (MSHQ-EjD), all assessed at 3 and 6 months relative to baseline. The IIEF captures erectile function, orgasmic function, sexual desire, intercourse satisfaction, and overall satisfaction [13]. The MSHQ-EjD measures the frequency, strength, and volume of ejaculation and the degree of bother [14]. Baseline demographic, clinical, and laboratory data were collected before surgery.

Statistical analysis

Continuous variables are summarized as mean and standard deviation. Normality was checked with the Shapiro-Wilk test. Between-group comparisons at each timepoint used the independent-samples t test or the Mann-Whitney U test, and categorical variables were compared with the chi-square test. Within-group change was assessed with the paired t test or the Wilcoxon signed-rank test. To model change over time, a two-way mixed analysis of variance was used with time as a within-subject factor and technique as a between-subject factor, followed by Bonferroni-corrected pairwise contrasts; partial eta squared and

Hedges' g were reported as effect sizes. Because serum prolactin and educational level differed at baseline, an analysis of covariance was applied to the 6-month scores, adjusting for the corresponding baseline score, prolactin, and education. Responder outcomes, including a clinically important improvement in erectile function (an increase of at least 4 points) and the incidence of de novo erectile dysfunction, were compared with the Fisher exact test, with 95% confidence intervals calculated by the Wilson method. Subgroup analyses were performed by diabetes status, baseline erectile function, age, and prostate size. A two-sided p-value below 0.05 was considered statistically significant. Analyses were performed in Python (SciPy, statsmodels, and pingouin).

Results

Participant Flow and Baseline Characteristics

A total of 80 men with a prostate volume greater than 60 g were randomized in equal numbers to bipolar enucleation of the prostate (BipoLEP, n = 40) or holmium laser enucleation of the prostate (HoLEP, n = 40). Randomization used sealed opaque envelopes, and outcome assessors were blinded to allocation. One participant in the BipoLEP arm was lost to follow-up after allocation and contributed no post-operative data; the remaining 79 men (BipoLEP n = 39, HoLEP n = 40) completed the 3- and 6-month assessments and were analyzed. The flow of participants through the trial is shown in Fig. 1.

Baseline demographic, clinical, and laboratory characteristics are presented in Table 1. The two arms were comparable on age, prostate volume, prostate-specific antigen, testosterone, glycated hemoglobin, and the remaining metabolic parameters (all $p > 0.05$). Two baseline variables differed between arms: serum prolactin ($p = 0.028$) and educational level ($\chi^2(2) = 19.05$, $p < .001$), with a higher proportion of university-educated men in the HoLEP arm. Both variables were carried forward as covariates in a sensitivity analysis (see below).

Table 1
Baseline Characteristics of the Two Treatment Arms

Characteristic	BipoLEP (n = 40)	HoLEP (n = 40)	p
Age (years)	61.80 ± 2.48	62.30 ± 2.51	0.370
Prostate volume (g)	92.22 ± 22.08	94.12 ± 19.04	0.600
PSA (ng/mL)	1.31 ± 0.30	1.29 ± 0.25	0.903
Prolactin (ng/mL)	16.88 ± 14.50	13.60 ± 14.28	0.028
Testosterone (ng/mL)	3.22 ± 1.23	3.50 ± 1.21	0.307
HbA1c (%)	6.71 ± 0.41	6.70 ± 0.49	0.836
Total cholesterol (mg/dL)	275.88 ± 60.47	265.95 ± 63.34	0.476
Triglycerides (mg/dL)	200.15 ± 28.77	195.32 ± 30.23	0.551
TSH (μIU/mL)	2.53 ± 1.06	2.39 ± 1.12	0.560
Testicular size (mL)	22.38 ± 6.20	22.12 ± 5.05	0.925
Education — Primary, n (%)	5 (12%)	0 (0%)	< 0.001
Education — Secondary, n (%)	17 (42%)	4 (10%)	
Education — University, n (%)	18 (45%)	36 (90%)	
<i>Note. Values are mean ± SD unless otherwise indicated. BipoLEP = bipolar enucleation of the prostate; HoLEP = holmium laser enucleation of the prostate. p values from independent-samples t test or Mann–Whitney U test for continuous variables and the chi-square test for educational level.</i>			

Sexual Function Over Time: Between-Group Comparison

IIEF-15 domain and total scores at each assessment are summarized in Table 2 and the trajectories are displayed in Fig. 2. At the pre-operative assessment, the two arms did not differ on any IIEF-15 domain or on the total score (all $p > 0.05$). This equivalence was maintained at every subsequent timepoint: no between-group difference reached statistical significance for any erectile-function, orgasmic-function, sexual-desire, intercourse-satisfaction, or overall-satisfaction domain, or for the IIEF-15 total, at 3 months or at 6 months (all $p > 0.05$). At 3 months the erectile-function comparison was the closest to the conventional threshold (21.64 ± 4.50 for BipoLEP vs 23.25 ± 3.24 for HoLEP, $p = 0.073$) but did not reach significance; by 6 months the two arms had converged (24.97 ± 3.14 vs 25.57 ± 3.00 , $p = 0.468$). Thus, neither technique demonstrated superiority in sexual-function recovery at any timepoint.

Table 2
IIEF-15 Domain and Total Scores by Technique and Timepoint

Domain (score range)	Timepoint	BipoLEP	HoLEP	p
Erectile function (6–30)	Pre-operative	22.43 ± 3.14	23.18 ± 3.17	0.234
	3 months	21.64 ± 4.50	23.25 ± 3.24	0.073
	6 months	24.97 ± 3.14	25.57 ± 3.00	0.468
Orgasmic function (2–10)	Pre-operative	7.22 ± 1.33	7.65 ± 1.51	0.141
	3 months	7.67 ± 1.84	8.05 ± 1.32	0.503
	6 months	8.28 ± 1.41	8.72 ± 1.22	0.171
Sexual desire (2–10)	Pre-operative	7.60 ± 1.45	7.45 ± 1.38	0.572
	3 months	7.41 ± 1.58	7.78 ± 1.17	0.335
	6 months	8.26 ± 1.29	8.55 ± 1.11	0.368
Intercourse satisfaction (0–15)	Pre-operative	11.68 ± 1.94	11.88 ± 1.65	0.942
	3 months	10.82 ± 2.38	11.35 ± 2.13	0.249
	6 months	12.33 ± 1.63	12.80 ± 1.64	0.145
Overall satisfaction (2–10)	Pre-operative	7.55 ± 1.43	7.70 ± 1.56	0.586
	3 months	7.44 ± 1.60	8.05 ± 1.38	0.105
	6 months	8.44 ± 1.14	8.53 ± 1.04	0.774
IIEF-15 total (5–75)	Pre-operative	56.48 ± 7.10	57.85 ± 6.81	0.375
	3 months	54.97 ± 8.23	58.48 ± 6.26	0.060
	6 months	62.28 ± 7.63	64.17 ± 7.07	0.377
<i>Note. Values are mean ± SD. p values from independent-samples t test or Mann–Whitney U test comparing the two techniques at each timepoint. No between-group comparison was statistically significant.</i>				

Within-Technique Change From Baseline to 6 Months

Both techniques produced significant within-arm improvement in sexual function from baseline to 6 months (Table 3, Fig. 3). In a two-way mixed analysis of variance with time as a within-subject factor and technique as a between-subject factor, the main effect of time was significant for every outcome (all $p < .001$; Table 4), whereas the time $\times$ technique interaction was non-significant for every outcome (all $p > 0.43$), indicating parallel recovery profiles. Bonferroni-corrected post-hoc contrasts confirmed that scores did not change between baseline and 3 months (all corrected $p > 0.17$) and rose significantly

between 3 and 6 months, so that the net baseline-to-6-month gain was significant for erectile function, orgasmic function, and the IIEF-15 total in both arms, with medium-to-large effect sizes (Hedges $g = 0.77-0.90$). This pattern indicates a stable early period followed by improvement above baseline by 6 months. The between-subject main effect of technique was significant for erectile function ($p = 0.026$), orgasmic function ($p = 0.025$), and the IIEF-15 total ($p = 0.018$); this reflects the slightly higher scores already present in the HoLEP arm before surgery, and the effect was no longer significant once the baseline score was accounted for in the analysis of covariance (Table 5).

Table 3
Within-Technique Change in IIEF-15 Scores From Baseline to 6 Months

Domain (score range)	BipoLEP $\Delta \pm$ SD	p	d_z	HoLEP $\Delta \pm$ SD	p	d_z
Erectile function (6–30)	+ 2.59 $\pm$ 5.17	0.003	0.50	+ 2.40 $\pm$ 4.42	0.001	0.54
Orgasmic function (2–10)	+ 1.13 $\pm$ 2.05	0.001	0.55	+ 1.07 $\pm$ 1.98	0.001	0.54
Sexual desire (2–10)	+ 0.72 $\pm$ 1.97	0.028	0.36	+ 1.10 $\pm$ 1.88	0.002	0.59
Intercourse satisfaction (0–15)	+ 0.64 $\pm$ 2.97	0.186	0.22	+ 0.93 $\pm$ 2.54	0.026	0.36
Overall satisfaction (2–10)	+ 0.90 $\pm$ 1.96	0.007	0.46	+ 0.82 $\pm$ 2.11	0.018	0.39
IIEF-15 total (5–75)	+ 5.97 $\pm$ 12.21	0.004	0.49	+ 6.33 $\pm$ 10.56	< 0.001	0.60
<i>Note. Δ = mean change (6 months – baseline). p values from paired-samples t test or Wilcoxon signed-rank test; d_z = Cohen's effect size for paired data.</i>						

Table 4
Two-Way Mixed ANOVA (Time $\times$ Technique) for IIEF-15 Outcomes

Outcome	F (time)	p (time)	ηp^2 (time)	p (technique)	p (interaction)
Erectile function	16.10	< .001	0.173	0.026	0.617
Orgasmic function	11.98	< .001	0.135	0.025	0.969
Sexual desire	11.10	< .001	0.126	0.274	0.518
Intercourse satisfaction	11.93	< .001	0.134	0.124	0.831
Overall satisfaction	8.92	< .001	0.104	0.107	0.436
IIEF-15 total	20.69	< .001	0.212	0.018	0.656
<i>Note. Time factor: pre-operative, 3 months, 6 months (within-subject). Technique factor: BipoLEP vs HoLEP (between-subject). ηp^2 = partial eta squared. The interaction term was non-significant for every outcome, indicating comparable recovery in the two arms.</i>					

Table 5
ANCOVA of 6-Month IIEF-15 Scores Adjusted for Baseline Score, Prolactin, and Education

Outcome	Adj. diff (HoLEP – BipoLEP)	95% CI	p
Erectile function	+ 1.12	[-0.46, + 2.71]	0.161
IIEF-15 total	+ 2.96	[-0.73, + 6.65]	0.115
Orgasmic function	+ 0.56	[-0.14, + 1.25]	0.113
Overall satisfaction	+ 0.09	[-0.47, + 0.64]	0.757
Intercourse satisfaction	+ 0.66	[-0.17, + 1.48]	0.119
Sexual desire	+ 0.42	[-0.19, + 1.03]	0.176
<i>Note. Adjusted difference in 6-month score (positive = higher in HoLEP) from analysis of covariance with baseline domain score, serum prolactin, and educational level as covariates. All comparisons were non-significant.</i>			

Because serum prolactin and educational level were imbalanced at baseline, an analysis of covariance was performed on the 6-month scores adjusting for the corresponding baseline score, prolactin, and educational level (Table 5). After adjustment, the technique effect remained non-significant for every outcome (all $p > 0.11$; all 95% confidence intervals for the adjusted BipoLEP–HoLEP difference included zero), confirming that the equivalence of the two techniques was robust to these baseline differences.

Subgroup Analyses

Pre-specified subgroups were examined for a between-technique difference in the baseline-to-6-month change in IIEF-15 total score (Fig. 4, Table 6). No subgroup showed a significant difference between techniques (all $p > 0.25$). The largest within-patient gains were observed in men with diabetes and in men with baseline erectile dysfunction, and these gains were essentially identical for the two techniques. Men with normal baseline erectile function showed little net change, consistent with a ceiling effect. The confidence intervals for every subgroup comparison crossed zero (Fig. 4).

Table 6
Between-Technique Difference in IIEF-15 Total Change by Subgroup

Subgroup	n (Bipo/HoLEP)	BipoLEP $\Delta \pm$ SD	HoLEP $\Delta \pm$ SD	Difference	p
Overall	39/40	+ 5.97 $\pm$ 12.21	+ 6.33 $\pm$ 10.56	-0.35	0.934
Diabetic	29/29	+ 7.21 $\pm$ 12.37	+ 7.38 $\pm$ 10.48	-0.17	0.938
Non-diabetic	10/11	+ 2.40 $\pm$ 11.59	+ 3.55 $\pm$ 10.74	-1.15	0.888
Baseline ED	31/27	+ 7.55 $\pm$ 12.21	+ 8.07 $\pm$ 12.01	-0.53	0.809
Normal EF	8/13	-0.12 $\pm$ 10.82	+ 2.69 $\pm$ 5.34	-2.82	0.856
Prostate 60–100 g	25/25	+ 8.16 $\pm$ 11.97	+ 6.84 $\pm$ 10.71	+ 1.32	0.522
Prostate > 100 g	14/15	+ 2.07 $\pm$ 12.07	+ 5.47 $\pm$ 10.60	-3.40	0.359
Age < 65 y	32/30	+ 6.00 $\pm$ 11.21	+ 4.20 $\pm$ 10.19	+ 1.80	0.503
Age $\geq$ 65 y	7/10	+ 5.86 $\pm$ 17.17	+ 12.70 $\pm$ 9.39	-6.84	0.260
<i>Note. Δ = mean change (6 months – baseline) in IIEF-15 total. p values from Mann–Whitney U test. DM subgroups defined by HbA1c $\geq$ 6.5%; baseline ED defined by pre-operative erectile-function score < 26.</i>					

Clinical Responder Outcomes

Clinically anchored outcomes are summarized in Table 7. The proportion of men achieving a minimal clinically important improvement in erectile function ($\geq$ 4-point gain) at 6 months was similar between arms (BipoLEP 41.0%, HoLEP 35.0%; Fisher exact $p = 0.647$). Among men with normal baseline erectile function, the incidence of de novo erectile dysfunction at 6 months did not differ significantly (BipoLEP 4/8, HoLEP 4/13; $p = 0.646$). Any improvement in IIEF-15 total score at 6 months was observed in the majority of patients in both arms (69.2% vs 75.0%; $p = 0.622$).

Table 7
Clinical Responder Outcomes at 6 Months

Outcome	BipoLEP (95% CI)	HoLEP (95% CI)	p
EF responder ($\Delta \geq 4$ pts), 6 mo	16/39 (41.0%) [27, 57]	14/40 (35.0%) [22, 50]	0.647
De novo ED (normal→ED), 6 mo	4/8 (50.0%) [22, 78]	4/13 (30.8%) [13, 58]	0.646
Any IIEF-15 total improvement, 6 mo	27/39 (69.2%) [54, 81]	30/40 (75.0%) [60, 86]	0.622
<i>Note. Values are n/N (%) with 95% Wilson confidence interval. p values from Fisher exact test. MCID = minimal clinically important difference (≥ 4-point improvement in erectile function).</i>			

Ejaculatory Function (MSHQ-EJD)

Ejaculatory function was assessed with the ejaculatory-dysfunction domain of the Male Sexual Health Questionnaire (MSHQ-EJD) pre-operatively and at 3 and 6 months. Between-group comparisons at each timepoint are presented in Table 8, and the within-group change over time in each arm is presented in Table 9.

Table 8
MSHQ-EJD Ejaculatory Domain Scores by Technique and Timepoint

Domain	Pre-operative		3 months		6 months	
	BipoLEP	HoLEP	BipoLEP	HoLEP	BipoLEP	HoLEP
Frequency of ejaculation	2.23 ± 0.9	2.10 ± 0.9	2.00 ± 1.0	1.78 ± 0.8	2.43 ± 0.8	2.08 ± 0.9
<i>p value</i>	0.267		0.129		0.032*	
Strength of ejaculation	1.55 ± 1.0	1.08 ± 0.8	1.50 ± 1.2	1.25 ± 1.1	1.80 ± 1.2	1.33 ± 1.1
<i>p value</i>	0.165		0.061		0.037*	
Quantity of fluid with ejaculation	1.80 ± 1.0	1.05 ± 0.8	1.60 ± 1.1	1.50 ± 1.2	1.78 ± 1.2	1.68 ± 1.0
<i>p value</i>	0.378		0.010*		0.151	
Ejaculation bother	2.48 ± 1.5	3.08 ± 1.2	2.20 ± 1.3	2.45 ± 1.2	3.13 ± 1.0	2.93 ± 1.2
<i>p value</i>	0.181		0.040*		0.035*	
Total score	7.53 ± 2.4	7.48 ± 2.3	8.28 ± 2.5	7.03 ± 1.9	8.48 ± 2.5	7.98 ± 2.0
<i>p value</i>	0.461		0.007*		0.045*	
<i>Note. Values are mean ± SD; p values are the between-group comparison at each timepoint (independent-samples t test). * p < 0.05. Higher scores indicate better ejaculatory function except for ejaculation bother.</i>						

Table 9
Within-Technique Change in MSHQ-EJD Scores Across Follow-up

Domain	Pre-operative	3 months	6 months	ANOVA F	p
Group I (BipoLEP)					
Frequency of ejaculation	2.23 ± 0.9	2.00 ± 1.0	2.43 ± 0.8	4.28	0.031*
Strength of ejaculation	1.55 ± 1.0	1.50 ± 1.2	1.80 ± 1.2	5.28	0.021*
Quantity of fluid with ejaculation	1.80 ± 1.0	1.60 ± 1.1	1.78 ± 1.2	4.08	0.049*
Ejaculation bother	2.48 ± 1.5	2.20 ± 1.3	3.13 ± 1.0	6.02	0.016*
Total score	7.53 ± 2.4	8.28 ± 2.5	8.48 ± 2.5	5.11	0.028*
Group II (HoLEP)					
Frequency of ejaculation	2.10 ± 0.9	1.78 ± 0.8	2.08 ± 0.9	4.82	0.038*
Strength of ejaculation	1.08 ± 0.8	1.25 ± 1.1	1.33 ± 1.1	7.25	0.001*
Quantity of fluid with ejaculation	1.05 ± 0.8	1.50 ± 1.2	1.68 ± 1.0	8.02	0.001*
Ejaculation bother	3.08 ± 1.2	2.45 ± 1.2	2.93 ± 1.2	5.14	0.023*
Total score	7.48 ± 2.3	7.03 ± 1.9	7.98 ± 2.0	5.01	0.027*
<i>Note. Values are mean ± SD. F and p values from one-way ANOVA across the three timepoints within each technique. * p < 0.05.</i>					

At the pre-operative assessment the two techniques did not differ on any ejaculatory domain or on the MSHQ-EJD total score (all $p > 0.05$). At 3 months, the groups differed significantly in the quantity of fluid with ejaculation, ejaculation bother, and the total score (all $p < 0.05$). At 6 months, significant between-group differences were present for the frequency of ejaculation, strength of ejaculation, ejaculation bother, and the total score (all $p < 0.05$), with the BipoLEP arm (Group I) showing the higher ejaculatory total score (8.48 ± 2.5 vs 7.98 ± 2.0). Within each technique, one-way analysis of variance across the three timepoints showed a significant change over time for every ejaculatory domain and for the total score in both the BipoLEP and HoLEP arms (all $p < 0.05$; Table 9).

Discussion

In this two-center randomized trial we compared bipolar and holmium laser enucleation of the prostate on sexual function in men with a prostate larger than 60 g. Both techniques were followed by meaningful gains in erectile function and overall sexual satisfaction by six months, and the two arms recovered to a similar degree. The main difference between them appeared in the ejaculatory domain, where bipolar enucleation was associated with somewhat better MSHQ-EJD scores at three and six months. Taken

together, the results suggest that the choice of energy has little effect on erectile recovery but may matter for ejaculatory outcomes.

Erectile function, together with intercourse and overall satisfaction, is often the outcome that patients ask about first, and it is the domain most closely tied to their willingness to undergo surgery. In our cohort the two techniques did not differ on any IIEF erectile-domain score at baseline, three months, or six months. Scores in both arms were stable in the early period and then rose above baseline by six months, and a mixed-model analysis showed a clear effect of time with no time-by-technique interaction. This pattern does not support the idea of an early advantage for either method, and it argues against a transient decline that then recovers. A plausible explanation is that relief of bladder-outlet obstruction improves urinary symptoms and, with them, sexual confidence and satisfaction, an association that has been described across surgical approaches to LUTS [16]. Careful enucleation along the capsular plane may also spare the periprostatic neurovascular tissue that supports erection [5]. Our findings are consistent with a network meta-analysis suggesting that the various surgical treatments for LUTS have broadly similar effects on erectile function [8]. They also align with randomized data comparing diode laser and bipolar enucleation, in which erectile scores improved comparably and did not differ between arms at any time [15]. A related trial of diode laser versus bipolar enucleation likewise found no difference in erectile scores through twelve months [17]. Longer-term single-arm data after bipolar enucleation show a small rise in erectile function over five years, which fits the direction we observed [18]. Work comparing GreenLight and holmium enucleation has also reported little change in erectile function after either laser, again pointing to similarity between energies rather than superiority of one [19].

Not all reports agree, and the differences are worth considering. One study of GreenLight enucleation described a gradual improvement in erectile scores that was not seen after photoselective vaporization, a divergence the authors linked partly to the need for repeat treatment in the vaporization group [20]. By contrast, a prospective trial of plasmakinetic enucleation found a marked fall in the orgasmic-function component of the IIEF, which the authors attributed to a high rate of retrograde ejaculation after surgery [21]. We did not observe a comparable decline in orgasmic scores, and the difference may reflect our shorter follow-up, differences in case mix, or the way orgasmic and ejaculatory function were captured by separate instruments in our study.

Ejaculatory function deserves particular attention, because ejaculatory dysfunction is the most common sexual side effect after prostate surgery and is driven mainly by disruption of the bladder neck during tissue removal [9]. Here the two techniques did differ. Bipolar enucleation was associated with higher ejaculatory frequency and strength, less ejaculation-related bother, and a higher MSHQ-EjD total score at six months, along with differences in fluid volume, bother, and total score at three months. Within each arm, ejaculatory scores changed significantly across the follow-up period. A possible explanation is that the pattern of energy spread and bladder-neck handling differs between bipolar plasmakinetic and holmium laser enucleation, and that these technical differences influence how well antegrade ejaculation is preserved. This interpretation should be made cautiously, since the mechanism is not established and

the between-group differences were modest. Our observation contrasts with a recent series in which ejaculatory scores fell substantially after holmium enucleation, with the largest drops in items covering ejaculatory ability, strength, and volume [22]. It is broadly in keeping with reports that some laser techniques may not fully protect ejaculation and that the causes remain unclear [23]. Randomized comparisons of bipolar and monopolar resection have found little effect on erectile function, but they were not designed to capture the finer ejaculatory differences that dedicated instruments detect [24]. Similarly, a randomized comparison of photoselective vaporization and standard prostatectomy showed no meaningful difference in the reduction of antegrade flow [25].

Two baseline variables, serum prolactin and educational level, differed between the arms. To make sure these imbalances did not drive our results, we adjusted the six-month scores for baseline score, prolactin, and education, and the technique effect remained non-significant for every erectile-domain outcome. Pre-specified subgroup analyses pointed in the same direction: no subgroup, whether defined by diabetes, baseline erectile function, age, or prostate size, showed a between-technique difference. The largest within-patient gains were seen in men with diabetes and in men with erectile dysfunction at baseline, which is consistent with greater room for improvement in men who start with poorer function.

Clinical implications

Both procedures appear to be reasonable choices for men with large prostates who are concerned about sexual function. For erectile recovery the two techniques seem interchangeable, so the decision can rest on cost, equipment availability, and surgeon experience, with bipolar enucleation offering a lower-cost option where a laser is not available [6]. The modest ejaculatory advantage seen with bipolar enucleation may be relevant for men who place a high value on preserving ejaculation, and it is worth discussing during counselling.

Strengths, limitations, and future directions

The strengths of this study include its randomized, two-center design, the prospective follow-up, and the use of separate validated instruments for erectile and ejaculatory function. Several limitations temper the findings. Follow-up extended only to six months, so late changes may have been missed, and one participant in the bipolar arm was lost to follow-up. The baseline imbalance in prolactin and education, although addressed by adjustment, may reflect differences between the two centers. Larger multicenter trials with longer follow-up are needed, and future work should try to separate the effect of the enucleation technique from the effect of the energy used, since both may contribute.

Conclusions

Bipolar and holmium laser enucleation produced comparable improvements in erectile function and overall sexual satisfaction over six months, with no evidence that either technique was superior for erectile recovery at any point. Bipolar enucleation was associated with somewhat better ejaculatory outcomes. These results suggest that both procedures are effective options for men with large

prostates, and that ejaculatory function, rather than erectile function, may be the more useful consideration when choosing between them.

Abbreviations

ANCOVA

Analysis of covariance

ANOVA

Analysis of variance

BipoLEP

Bipolar enucleation of the prostate

BPH

Benign prostatic hyperplasia

CI

Confidence interval

CONSORT

Consolidated Standards of Reporting Trials

ED

Erectile dysfunction

HbA1c

Glycated hemoglobin

HoLEP

Holmium laser enucleation of the prostate

IIEF

International Index of Erectile Function

LUTS

Lower urinary tract symptoms

MCID

Minimal clinically important difference

MSHQ-EjD

Male Sexual Health Questionnaire ejaculatory dysfunction short form

PSA

Prostate-specific antigen

SD

Standard deviation

SEM

Standard error of the mean

TURP

Transurethral resection of the prostate

Declarations

Author Contribution

Authors' contributions MAA and AD conceived and designed the study. AD and MA recruited participants and performed the surgical procedures. AAFE and MA collected and curated the clinical and questionnaire data. AD and MAA performed the statistical analysis and interpreted the results. AD drafted the manuscript. MAA, AAFE, and MA critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

Data Availability

The datasets generated and analyzed during the current study are not publicly available because participant consent did not cover open data deposition, but are available from the corresponding author (Ahmed Desouky, ahmedabdella5@gmail.com) on reasonable request.

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Figures

CONSORT Flow Diagram — BipoleP vs HoLEP Sexual-Function Trial

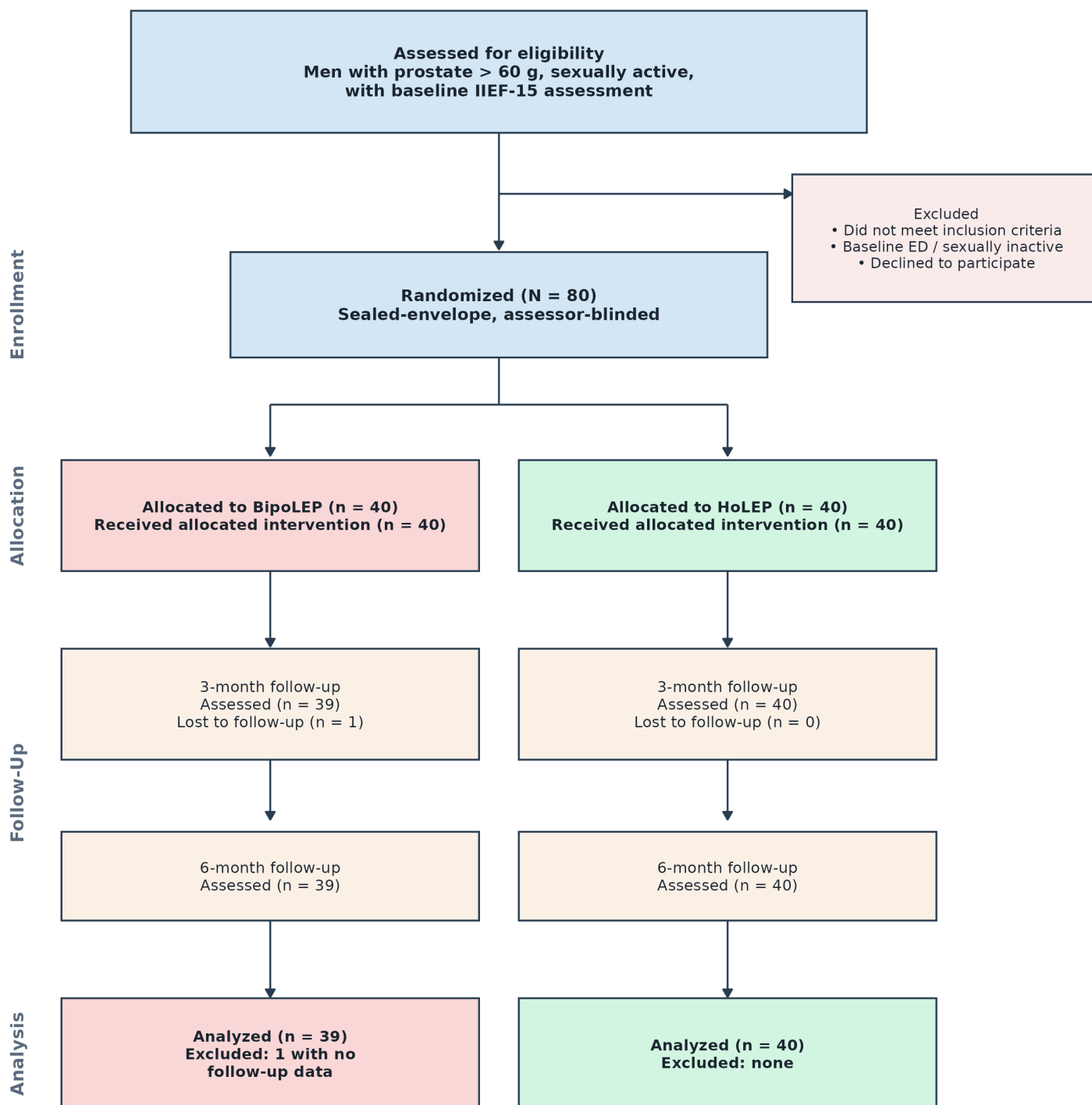


Figure 1

CONSORT flow diagram of participant enrollment, allocation, follow-up, and analysis.

Sexual-function trajectory by enucleation technique (mean $\pm$ SEM)

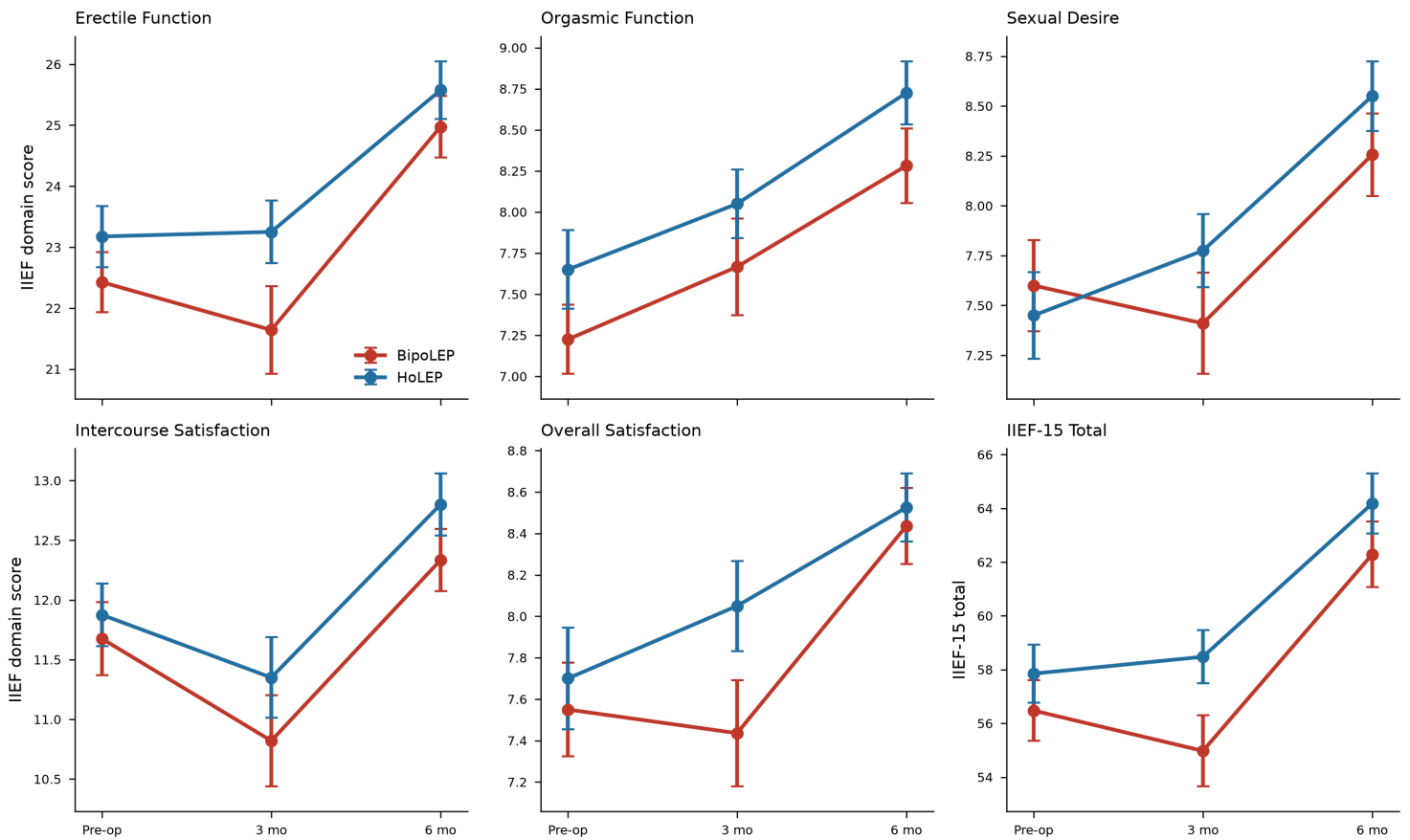


Figure 2

Mean ($\pm$ SEM) IIEF-15 domain and total scores from baseline to 6 months for the two techniques. Between-group differences were non-significant at every timepoint.

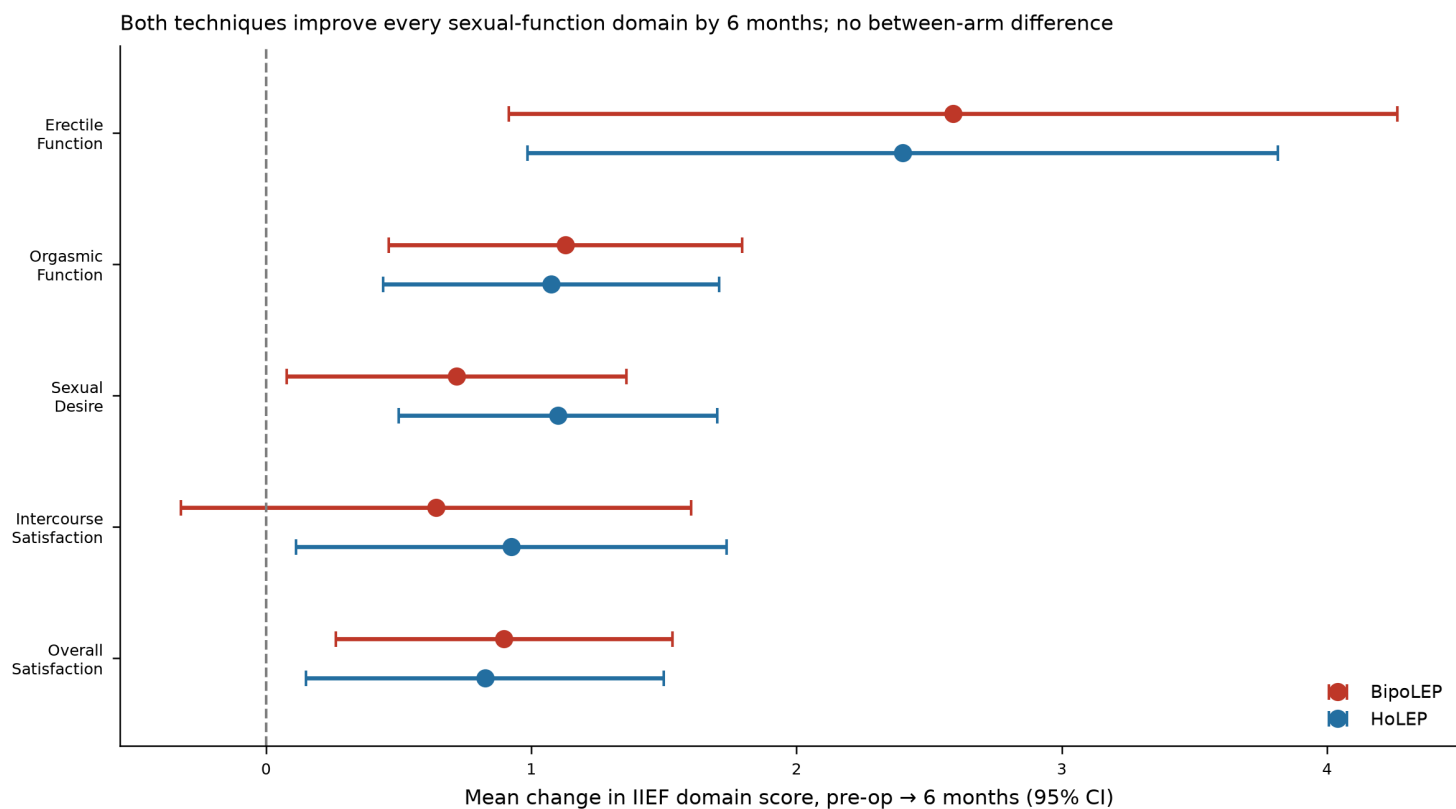


Figure 3

Mean baseline-to-6-month change in each IIEF-15 domain with 95% confidence intervals for the two techniques. Intervals excluding zero indicate significant within-arm improvement.

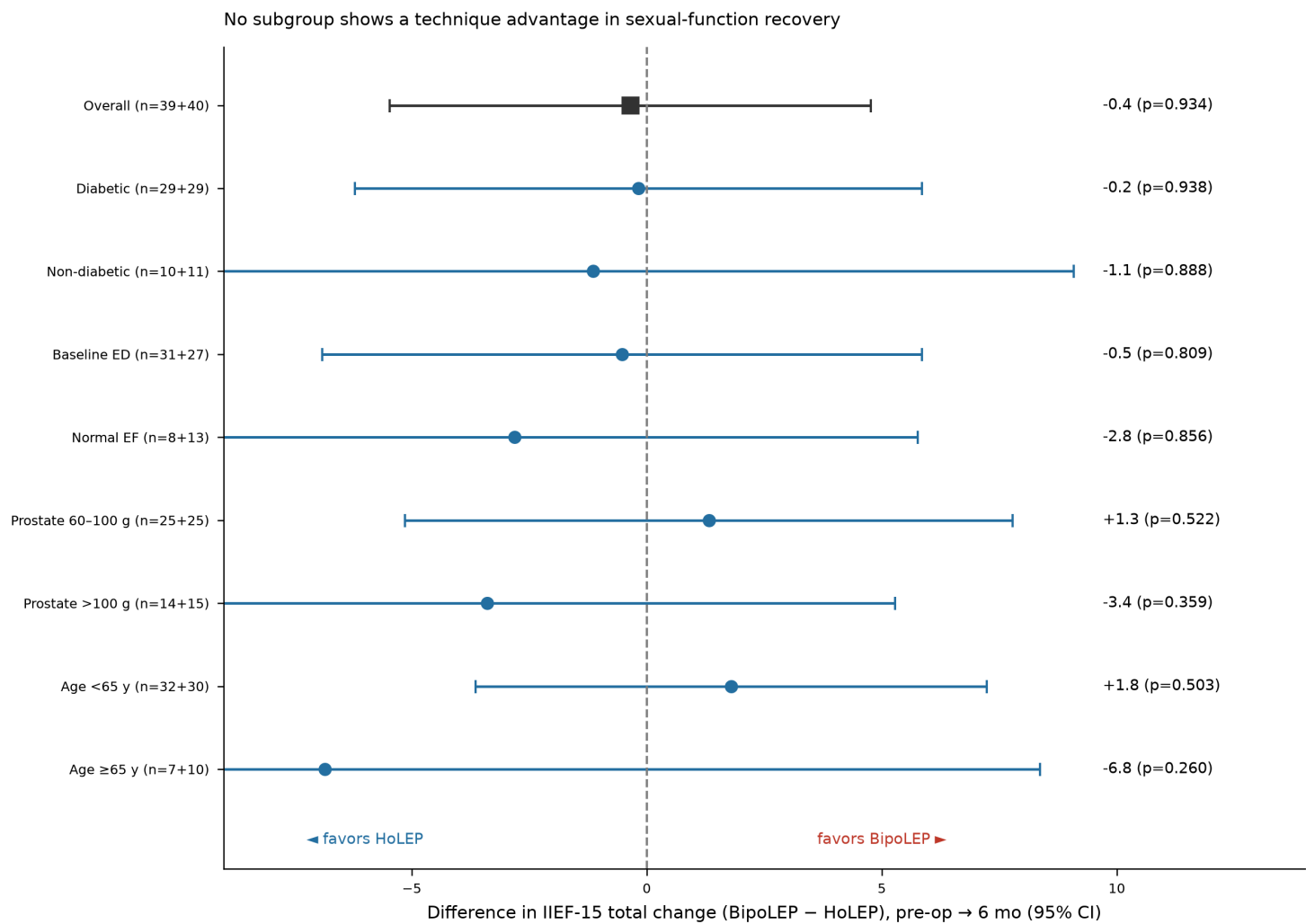


Figure 4

Forest plot of the between-technique difference (BipoLEP – HoLEP) in baseline-to-6-month IIEF-15 total change across pre-specified subgroups. All 95% confidence intervals include zero.