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ORIGINAL RESEARCH

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Are there benefits of varicocelectomy beyond semen parameters? Effects on sexual function and psychological well-being

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Abstract

Background: Varicocele is a common condition associated with impaired spermatogenesis and reduced testosterone production. While varicocelectomy is primarily indicated for infertility, its effect on sexual function and psychological status are less clearly defined. This study aimed to evaluate the impact of varicocelectomy on sexual, hormonal, and psychological outcomes beyond conventional semen parameters. **Methods**: This single-center retrospective cohort study included 81 men who underwent open subinguinal + inguinal varicocelectomy between 2022 and 2025. Preoperative and 6-month postoperative assessments included the International Index of Erectile Function-5 (IIEF-5), intravaginal ejaculatory latency time (IELT), libido score, Premature Ejaculation Test (PET), nocturnal penile tumescence (NPT) grade, serum total testosterone, and Beck Depression Inventory (BDI). Paired non-parametric tests were used for analysis, and subgroup comparisons were performed according to varicocele laterality (unilateral *vs.* bilateral). **Results**: At 6 months, significant postoperative changes were observed in multiple domains. Median serum total testosterone increased from 13.42 (4.23) to 15.04 (1.27) ng/mL ($p < 0.001$). Median libido score increased from 5 (3) to 8 (2), and PET score increased from 3 (1) to 4 (1) (both $p < 0.001$). Median IIEF-5 and IELT values remained numerically unchanged, although statistically significant paired differences were observed (both $p < 0.001$), suggesting that the magnitude of change in these parameters may have been limited. Semen parameters improved significantly in both unilateral and bilateral groups (all $p < 0.001$), with a between-group difference observed only for postoperative progressive motility. **Conclusions**: Varicocelectomy was associated with statistically significant changes in multiple sexual, hormonal, psychological, and semen parameters at 6-month follow-up. However, some changes were modest in magnitude and should be interpreted cautiously, particularly given the absence of a control group and the subjective nature of several outcomes.

Keywords

Varicocelectomy; Sexual function; Erectile dysfunction; Testosterone; Psychological well-being; Ejaculatory latency

¿Existen beneficios de la varicocelectomía más allá de los parámetros seminales? Efectos sobre la función sexual y el bienestar psicológico

Resumen

Antecedentes: El varicocele es una condición frecuente asociada con alteraciones en la espermatogénesis y disminución de la producción de testosterona. Aunque la varicocelectomía se indica principalmente por infertilidad, sus efectos sobre la función sexual y el estado psicológico no están completamente definidos. Este estudio tuvo como objetivo evaluar el impacto de la varicocelectomía sobre los parámetros sexuales, hormonales y psicológicos más allá de los parámetros seminales convencionales. **Métodos**: Este estudio retrospectivo de cohorte unicéntrico incluyó a 81 hombres sometidos a varicocelectomía abierta entre 2022 y 2025. Se realizaron evaluaciones preoperatorias y a los 6 meses postoperatorios, incluyendo el índice internacional de función eréctil (IIEF-5), el tiempo de latencia eyaculatoria intravaginal (IELT), la puntuación de libido, el test de eyaculación precoz (PET), el grado de tumescencia peneana nocturna (NPT), los niveles séricos de testosterona total y el inventario de depresión de Beck (BDI). Se utilizaron pruebas no paramétricas para el análisis. **Resultados**: A los 6 meses se observaron cambios significativos en múltiples parámetros. Los niveles de testosterona, la puntuación de libido y el control eyaculatorio mejoraron significativamente ($p < 0.001$). Aunque se detectaron diferencias estadísticas en IIEF-5 e IELT, los valores medianos permanecieron prácticamente sin cambios, lo que sugiere un impacto clínico limitado a nivel poblacional. Los parámetros seminales también mejoraron significativamente. **Conclusiones**: La varicocelectomía se asoció con mejoras en parámetros hormonales, sexuales, psicológicos y seminales. Sin embargo, algunos cambios fueron de magnitud limitada y deben interpretarse con cautela, especialmente considerando la ausencia de grupo control y la naturaleza subjetiva de varios resultados.

Palabras Clave

Varicocelectomía; Función sexual; Disfunción eréctil; Testosterona; Bienestar psicológico; Latencia eyaculatoria

1. Introduction

Varicocele, an abnormal dilatation of the pampiniform plexus, represents the most common correctable cause of male infertility. It affects approximately 15% of the general male population and is identified in up to 40% of men with primary infertility and nearly 80% with secondary infertility [1]. The underlying pathophysiology involves increased scrotal temperature, venous reflux, hypoxia, and oxidative stress, which may impair spermatogenesis and testosterone synthesis [2]. Consequently, varicocele has been associated with abnormal semen parameters and reduced serum testosterone levels.

Beyond its well-recognized impact on fertility, varicocele has gained attention for its broader effects on male health. Impaired Leydig cell function and decreased intratesticular testosterone production may contribute to hypogonadal symptoms, diminished libido, and erectile dysfunction [3]. Moreover, varicocele related pain and reduced sexual satisfaction can adversely affect psychological well-being. Recent studies suggest that varicocelectomy has been associated with improvements in semen quality, as well as potential improvements in sexual function and mood, with measurable gains in erectile function, ejaculatory control, and testosterone levels [4–6].

According to the European Association of Urology (EAU) guidelines, varicocelectomy is primarily recommended for infertile men with clinical varicocele and abnormal semen parameters, as well as for those with persistent scrotal pain. However, there is limited guidance regarding surgery performed solely to improve sexual function, hormonal status, or quality of life in men not actively pursuing fertility. This reflects an important gap in literature. Clarifying the broader health outcomes of varicocele repair is therefore essential to optimize patient counseling and clinical decision-making.

The present retrospective study investigates the effects of varicocelectomy on semen parameters, testosterone levels, sexual function, and psychological health in adult men with clinically diagnosed varicocele. By evaluating outcomes across different varicocele grades and laterality, we aimed to determine whether varicocele severity or patient characteristics are associated with postoperative improvements, and to further define the benefits of surgical repair beyond fertility.

2. Materials and methods

2.1 Study design

This study was a single-center retrospective cohort study conducted at İzmir Kâtip Çelebi University Faculty of Medicine Hospital. The study included adult men who underwent open subinguinal + inguinal varicocelectomy for a clinically palpable varicocele between January 2022 and March 2025. Although the final analysis was retrospective; all clinical variables were derived from a prospectively maintained institutional database that was initiated in early 2022.

2.2 Patient population

Eligible patients were identified through a systematic search of the hospital electronic medical record system. Patients were identified retrospectively from the institutional database; however, it could not be confirmed whether all consecutive cases were included. Patients aged 18 years or older with a clinically palpable Grade I–III varicocele, classified according to the grading system as small (Grade I), moderate (Grade II), or large (Grade III), were considered eligible. Both unilateral and bilateral varicoceles were included, and laterality was recorded for all patients. Varicocelectomy was performed for established clinical indications, including infertility associated with at least one abnormal semen parameter in the context of

couple infertility, chronic scrotal pain attributed to varicocele and refractory to conservative management, or hypogonadal symptoms and/or sexual-function complaints such as erectile dysfunction, reduced libido, or premature ejaculation.

Patients were excluded if they had a history of prior scrotal or inguinal surgery, evidence of non-varicocele-related hypogonadism, clinically significant psychiatric disorders that could influence sexual or psychological outcome measures, or incomplete clinical, laboratory, or follow-up data. During the study period, a total of 138 patients underwent open subinguinal + inguinal varicocelectomy. After application of the predefined eligibility criteria, 57 patients were excluded due to incomplete questionnaires (n = 32) or loss to follow-up (n = 25), resulting in a final analytical cohort of 81 patients. The flow chart of the study is presented in Fig. 1. Missing data were handled using listwise deletion; therefore, only patients with complete preoperative and postoperative datasets were included in the analysis.

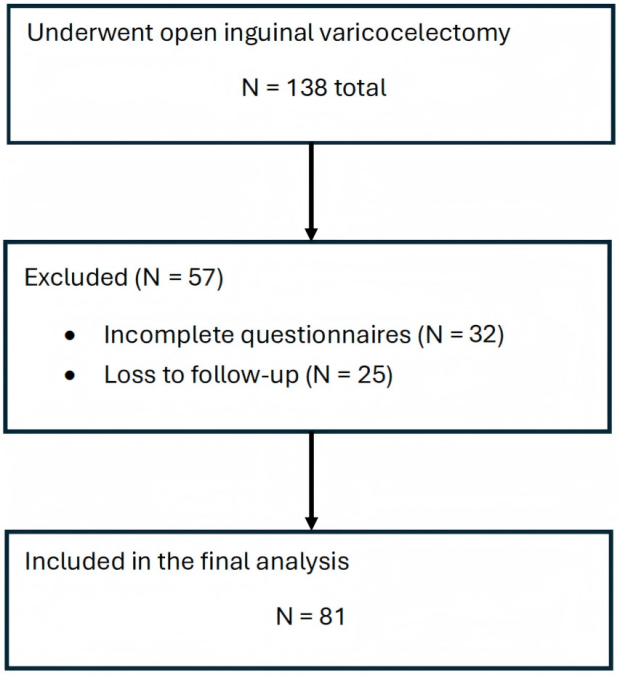

FIGURE 1. Flowchart of patient selection and study inclusion process.

2.3 Assessments

All patients underwent standardized preoperative and 6-month postoperative evaluations, including semen analysis, hormonal assessment, and validated questionnaires assessing sexual and psychological function.

2.3.1 Sexual function and ejaculatory parameters

Sexual function was evaluated with the 5-item International Index of Erectile Function (IIEF-5; score range 5–25, higher scores indicating better erectile function) [7]. Intravaginal ejaculatory latency time (IELT) was recorded in minutes based on the patient's subjective estimation of the average time from vaginal penetration to ejaculation [8]. Stopwatch-timed measurements were not used in this cohort, consistent with routine clinical practice. Ejaculatory control was assessed using the Premature Ejaculation Test (PET; scale 0–4, higher scores indicating better control) [9]. Libido was self-rated on a 0–10 visual analog scale [10].

2.3.2 Nocturnal penile tumescence

Nocturnal Penile Tumescence (NPT) was assessed based on subjective patient self-reporting using a standardized clinical grading scale, as objective monitoring devices (*e.g.*, RigiScan) were not routinely used in this cohort. Patients were asked to estimate the frequency, duration, and rigidity of their morning erections over the preceding 4 weeks. It was graded as 0 = none, 1 = weak/short erections (<10 min), 2 = moderate (10–30 min, ~50–60% rigidity), or 3 = normal nocturnal erections (≥30 min, >60% rigidity, ≥3 episodes/night).

2.3.3 Hormonal and psychological assessment

Serum total testosterone levels were measured using a standardized chemiluminescent immunoassay [11]. To minimize circadian variability, blood samples were obtained in the morning between 08.00–10.00 following an overnight fast. Measurements were performed at baseline and at 6 months postoperatively. Psychological status was assessed with the Beck Depression Inventory (BDI, total score 0–63), where scores 0–13 indicate minimal, 14–19 mild, 20–28 moderate, and ≥29 severe depressive symptoms [12].

2.3.4 Semen analysis

Semen samples were obtained after 2–5 days of abstinence and analyzed according to World Health Organization (WHO) guidelines. Parameters assessed included ejaculate volume (mL), sperm concentration (million/mL), progressive motility (%), and strict morphology (%) [13].

2.4 Surgical technique

All patients underwent open varicocelectomy via a standard subinguinal + inguinal approach due to the familiarity of surgeons with the anatomy of the inguinal canal [14]. While subinguinal repair is recognized as the reference standard, the open inguinal approach was the established standard of care at our institution during the study period, used based on equipment availability and institutional routine. The procedure was performed without the use of optical magnification or an operating microscope. Through a standard inguinal incision, the external oblique aponeurosis was incised to access the inguinal canal. The spermatic cord was mobilized, and high ligation of the dilated internal spermatic veins was performed while preserving the testicular artery and lymphatics, following conventional surgical practice.

2.5 Outcomes

The primary outcome of the study was the change in sexual function parameters, including IIEF-5 score, IELT, libido score, PET score, and NPT grade, between preoperative and 6-month postoperative assessments. Secondary outcomes included changes in serum total testosterone levels, BDI score, and semen parameters (volume, sperm concentration, progres-

sive motility, and morphology). All outcomes were assessed at baseline (preoperatively) and at 6 months postoperatively.

2.6 Statistical analysis

Normality of continuous variables was assessed using the Kolmogorov-Smirnov test. As most variables were not normally distributed, data were presented as median (interquartile range) and analyzed using non-parametric tests. Preoperative and postoperative continuous values were compared using the Wilcoxon signed-rank test, while comparisons between independent subgroups (*e.g.*, unilateral *vs.* bilateral varicocele) were conducted using the Mann-Whitney U test. Although McNemar's test was initially considered for the analysis of preoperative and postoperative NPT, it was not applicable in this study. NPT was measured on a four-level ordinal scale (none, weak, moderate, normal nocturnal erections), whereas McNemar's test is limited to dichotomous outcomes. In the postoperative assessment, no patient remained in the "none" NPT category, resulting in structural zero cells in the paired contingency table. This violated the assumptions required for McNemar's test and its multinomial extensions, which render the test statistic undefined. Therefore, changes in NPT were analyzed using the Wilcoxon signed-rank test, which is more appropriate for paired ordinal data. Missing data were managed by listwise deletion; no statistical imputation techniques were applied. To maintain statistical power in this exploratory analysis, a formal correction for multiple comparisons (*e.g.*, Bonferroni) was not applied; however, the potential risk of Type I error is acknowledged. All statistical analyses were performed using R (version 4.2.2.). A p value < 0.05 was considered statistically significant.

3. Results

3.1 Patient characteristics

A total of 81 patients were included in the analysis. The median age was 29 (12) years, and the median body mass index was 25 (3) kg/m^2. Most patients had left-sided varicocele (70.4%), while bilateral involvement was observed in 27.2%. Varicocele severity was predominantly Grade I–II (76.5%). Smoking was reported by 63.0% of patients. Baseline demographic and clinical characteristics are summarized in Table 1.

3.2 Baseline characteristics of the study population

Baseline characteristics were largely comparable between unilateral and bilateral varicocele groups. There were no significant differences in age, body mass index (BMI), smoking status, alcohol consumption, regular exercise, or most semen parameters (all $p > 0.05$). However, patients with bilateral varicocele had significantly higher varicocele grade, larger vein diameter, and a higher prevalence of testicular atrophy (all $p < 0.01$). In addition, baseline total testosterone and libido scores were significantly lower, while BDI scores were higher in the bilateral group compared to the unilateral group (all $p < 0.01$). NPT distribution also differed significantly between groups ($p < 0.001$).

TABLE 1. Baseline demographic and clinical characteristics of the study population (n = 81).

Variable	Median (IQR)/n (%)
Age	29 (12.0)
Body mass index (kg/m^2)	25 (3.0)
Vein diameter (mm)	3.0 (0.8)
Smoking status, n (%)	
No	30 (37.0)
Yes	51 (63.0)
Alcohol consumption, n (%)	
No	57 (70.4)
Yes	24 (29.6)
Regular exercise, n (%)	
No	37 (45.7)
Yes	44 (54.3)
Varicocele grade, n (%)	
Grade I	30 (37.0)
Grade II	32 (39.5)
Grade III	19 (23.5)
Laterality, n (%)	
Bilateral	22 (27.2)
Left	57 (70.4)
Right	2 (2.5)

Data are presented as median (IQR: interquartile range) or number (percentage), as appropriate.

3.3 Overall changes in sexual, hormonal and psychological outcomes

At the 6-month follow-up, significant improvements were observed across hormonal, sexual-function, and psychological parameters (Table 2). Median serum total testosterone increased from 13.42 (4.23) preoperatively to 15.04 (1.27) postoperatively ($p < 0.001$). Erectile function, assessed using the IIEF-5, showed a statistically significant paired change; however, the median score changed only minimally at follow-up, suggesting that the overall clinical impact at the cohort level may have been limited. Ejaculatory outcomes also demonstrated significant changes. Similarly, median intravaginal ejaculatory latency time remained numerically unchanged, despite a statistically significant paired difference ($p < 0.001$), indicating that this finding should be interpreted with caution in terms of clinical relevance. Ejaculatory control, measured by the Premature Ejaculation Test, improved from a median score of 3 (1) to 4 (1) at 6 months ($p < 0.001$). Sexual desire and psychological status improved in parallel. Median libido scores increased from 5 (3) preoperatively to 8 (2) postoperatively ($p < 0.001$), while median Beck Depression Inventory scores decreased from 16 (12) to 11 (4) over the same period ($p < 0.001$) (see Fig. 2 and **Supplementary Table 1**).

TABLE 2. Baseline characteristics according to varicocele laterality.

Characteristic	Unilateral (n = 59)	Bilateral (n = 22)	*p*-value
Age (yr)	29 (25–37)	31 (25–37)	0.800
BMI (kg/m^2)	25.00 (25.00–27.00)	25.00 (25.00–28.00)	0.700
Smoking status, n (%)	38 (64%)	13 (59%)	0.900
Alcohol consumption, n (%)	15 (25%)	9 (41%)	0.300
Regular exercise, n (%)	35 (59%)	9 (41%)	0.200
Varicocele grade, n (%)			
Grade I	30 (51%)	0 (0%)	
Grade II	22 (37%)	10 (45%)	<0.001
Grade III	7 (12%)	12 (55%)	
Vein diameter (mm)	3.00 (2.60–3.50)	3.50 (3.00–4.20)	0.002
Scrotal pain, n (%)	28 (47%)	12 (55%)	0.800
Testicular atrophy, n (%)	4 (6.8%)	9 (41%)	<0.001
Total testosterone (ng/mL)	13.9 (12.5–16.6)	10.9 (7.8–12.9)	<0.001
IIEF-5 score	25.00 (22.00–25.00)	24.00 (20.00–25.00)	0.600
IELT (min)	5.00 (3.00–6.00)	5.00 (3.00–5.00)	0.700
Libido score	5.00 (4.00–7.00)	4.00 (2.00–5.00)	0.004
PET score	3.00 (3.00–4.00)	3.00 (3.00–4.00)	0.500
NPT grade, n (%)			
0	2 (3.4%)	5 (23%)	
1	7 (12%)	16 (73%)	<0.001
2	35 (59%)	0 (0%)	
3	15 (25%)	1 (4.5%)	
BDI score	14 (12–17)	27 (25–32)	<0.001
Volume (mL)	3.50 (2.90–4.50)	3.40 (2.30–3.80)	0.200
Sperm concentration (million/mL)	15.6 (14.4–22.3)	14.6 (12.7–19.4)	0.300
Progressive motility (%)	30.0 (27.0–31.0)	29.0 (27.0–30.0)	0.400
Morphology (%)	4.00 (3.00–6.00)	3.00 (2.00–5.00)	0.077

Values are presented as median (Q1–Q3) or n (%). Continuous variables were compared using the Wilcoxon rank-sum test, and categorical variables using Pearson's chi-squared test. BMI: body mass index; IIEF-5: International Index of Erectile Function-5; IELT: intravaginal ejaculatory latency time; PET: Premature Ejaculation Test; NPT: nocturnal penile tumescence; BDI: Beck Depression Inventory.

3.4 NPT changes

NPT showed a significant improvement following surgery. Preoperatively, 7 patients (8.6%) had no nocturnal erections, 23 (28.4%) had weak erections, 35 (43.2%) had moderate erections, and 16 (19.8%) had normal nocturnal erections. Postoperatively, no patient remained in the "none" category, while 2 patients (2.5%) had weak erections, 19 (23.5%) had moderate erections, and 60 patients (74.1%) achieved normal nocturnal erections. Paired comparison of preoperative and postoperative NPT scores demonstrated a statistically significant improvement after surgery (Wilcoxon signed-rank test: V = 15.5, $p < 0.001$), with a large effect size ($r = 0.72$). Transition analysis revealed that all patients with absent preoperative NPT improved postoperatively, and most patients with weak or moderate preoperative NPT achieved normal nocturnal erections after surgery (see Fig. 3).

3.5 Erectile function and depression

At baseline, erectile dysfunction (IIEF-5 $\leq$21) was present in 24.7% of patients. A clinically meaningful improvement in erectile function ($\geq$4-point increase in IIEF-5) was observed in 19.8% of the cohort. Patients with baseline erectile dysfunction demonstrated a significantly greater median improvement in IIEF-5 score compared with those without erectile dysfunction (5.0 *vs.* 0.0, $p < 0.001$). Depressive symptoms (BDI $\geq$14) were present in 67.9% of patients at baseline. A clinically meaningful reduction in depressive symptoms ($\geq$5-point decrease in BDI) was observed in 61.7% of patients. Improvement in BDI scores was significantly greater among patients with baseline depressive symptoms than among those

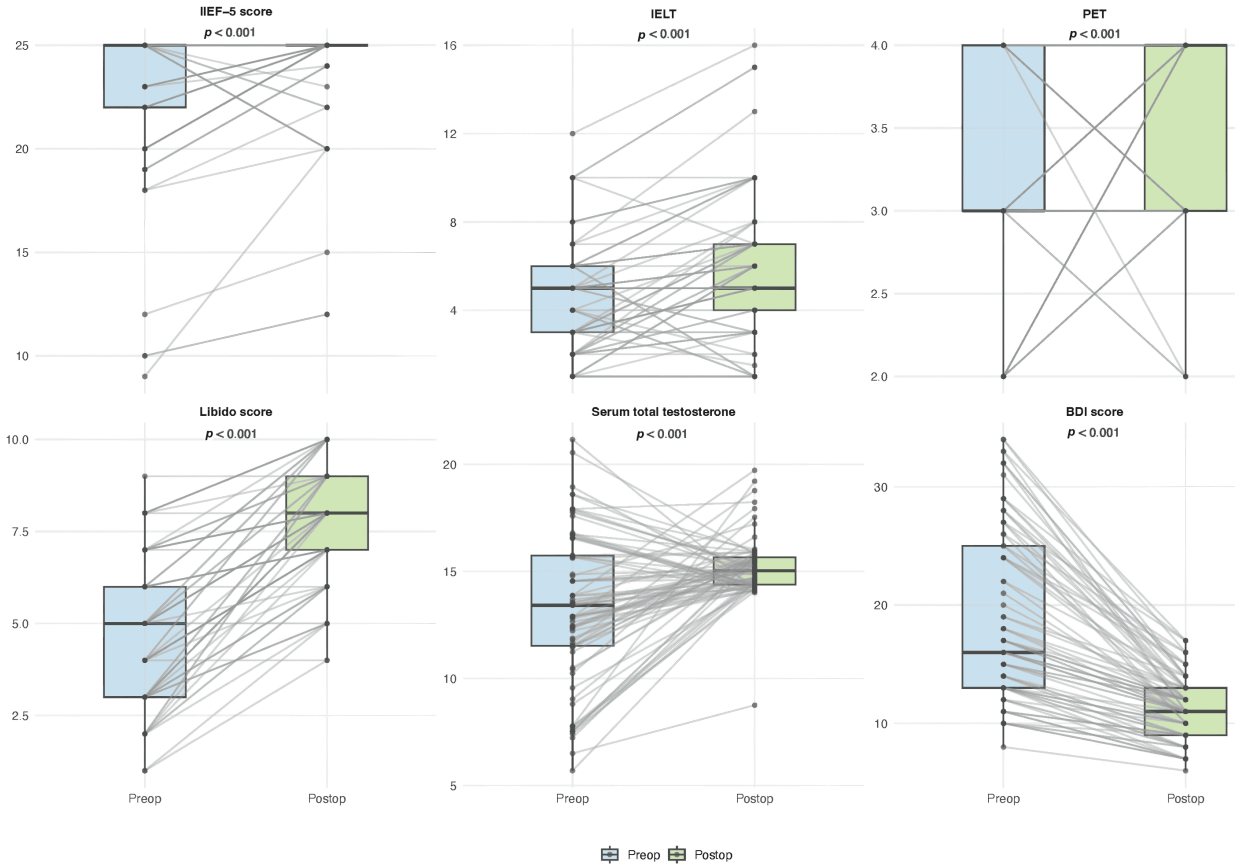

FIGURE 2. Changes in hormonal, sexual, and psychological outcomes after varicocelectomy. IIEF-5: International Index of Erectile Function-5; IELT: intravaginal ejaculatory latency time; PET: Premature Ejaculation Test; BDI: Beck Depression Inventory.

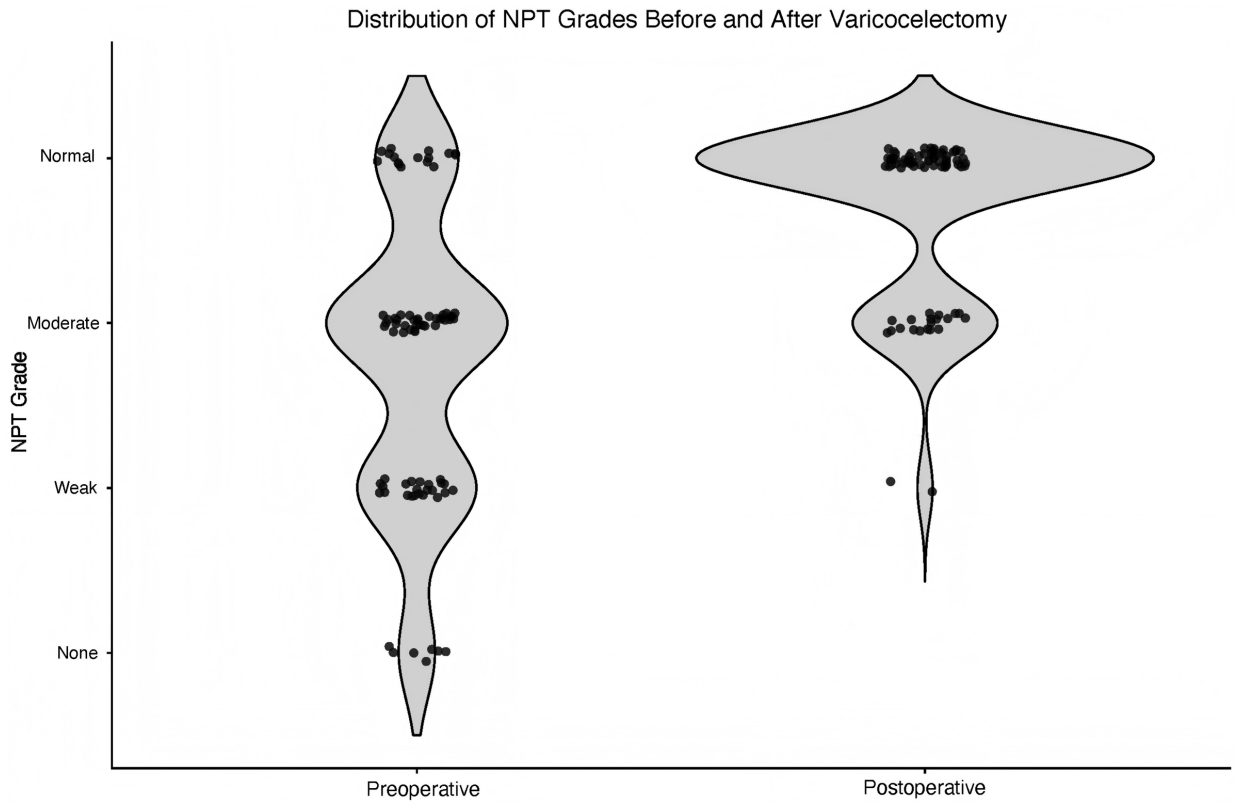

FIGURE 3. Changes in nocturnal penile tumescence grades before and after varicocelectomy. NPT: nocturnal penile tumescence.

without (−8.0 *vs.* −3.0, $p < 0.001$). These subgroup findings suggest that clinically meaningful benefit may have been concentrated in patients with baseline dysfunction, which may partly explain the modest overall median change observed at the cohort level.

3.6 Semen parameters

Following varicocelectomy, all conventional semen parameters demonstrated statistically significant postoperative improvement (**Supplementary Table 2**). Median ejaculate volume increased from 3.4 (1.5) mL to 4.3 (1.1) mL, while sperm concentration increased from 15.6 (7.0) to 20.4 (8.1) million/mL ($p < 0.001$ for both). Progressive motility improved from 29.0% (3.0) to 34.0% (3.0) , and strict morphology increased from 4.0% (2.0) to 6.0% (3.0), with all changes reaching statistical significance ($p < 0.001$) (see Fig. 4).

3.7 Varicocele laterality

Subgroup analysis according to varicocele laterality demonstrated significant within-group postoperative improvements in all semen parameters in both unilateral (n = 59) and bilateral (n = 22) cohorts (Table 3). In both groups, testicular volume, sperm concentration, progressive motility, and morphology increased significantly following surgery (all within-group $p < 0.001$). Between-group comparisons at the postoperative time point revealed no significant differences in testicular volume, sperm concentration, or morphology. However, progressive motility was significantly higher in the bilateral group compared with the unilateral group ($p = 0.0357$) (see Fig. 5 and **Supplementary Table 3**).

3.8 Pain and testicular atrophy

Preoperatively, 40 patients (49.4%) reported scrotal pain and 13 (16.0%) had clinical testicular atrophy. During follow-up, scrotal pain resolved in most cases and persisted in only a minority, while atrophy rates remained stable without further deterioration (see Table 4).

3.9 Complications and recurrence

Recurrence was observed in 14/81 patients (17.3%), the majority subclinical; only 2 (2.5%) were symptomatic and underwent redo surgery. No major intra- or postoperative complications were recorded. Based on clinical follow-up notes, transient hydrocele (~6%) and scrotal edema (~4%) occurred and resolved spontaneously.

4. Discussion

Varicocele is a common, potentially correctable condition associated with impaired male fertility. Despite being frequently encountered in clinical andrology, its pathophysiological mechanisms, diagnostic criteria, and therapeutic approaches remain areas of active investigation and debate. Emerging evidence supports the multifactorial pathophysiology of varicocele, involving oxidative stress, hypoxia, inflammatory pathways, and potential genetic predisposition. Biomarkers and advanced imaging modalities may improve diagnostic accuracy, while microsurgical

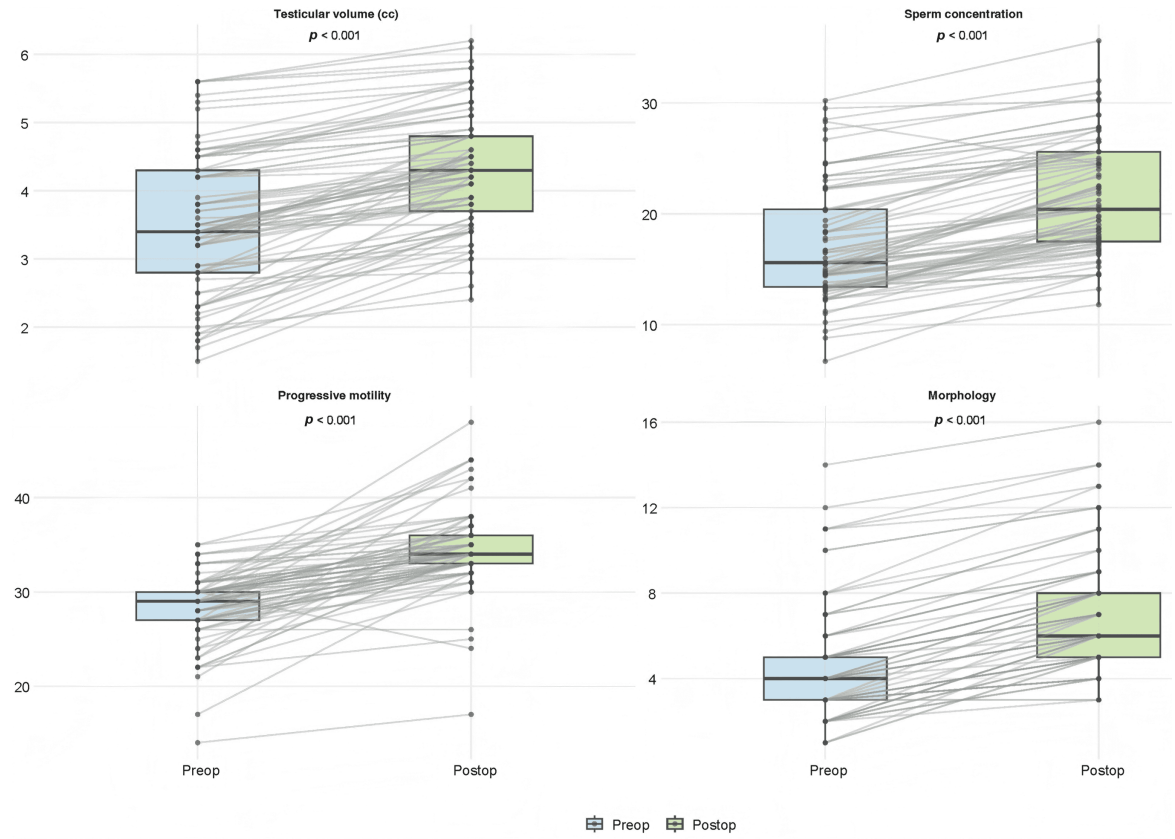

FIGURE 4. Changes in semen parameters following varicocelectomy.

TABLE 3. Within- and between-group comparisons of semen parameters according to varicocele laterality.

Variable	Unilateral (n = 59)	Bilateral (n = 22)	Within-group (*p*)	Between-group (*p*)
Testicular volume (cc)	3.5 (1.5) → 4.3 (1.25)	3.4 (1.3) → 4.3 (0.625)	<0.001	0.8691
Sperm concentration (million/mL)	15.6 (7.8) → 20.4 (7.2)	14.55 (6.5) → 20.8 (8.7)	<0.001	0.7783
Progressive motility (%)	30 (4) → 34 (3)	29 (3) → 35.5 (4.5)	<0.001	0.0357
Morphology (%)	4 (3) → 7 (4)	3 (2.5) → 6 (2.75)	<0.001	0.5486

Data are presented as median (IQR: interquartile range).

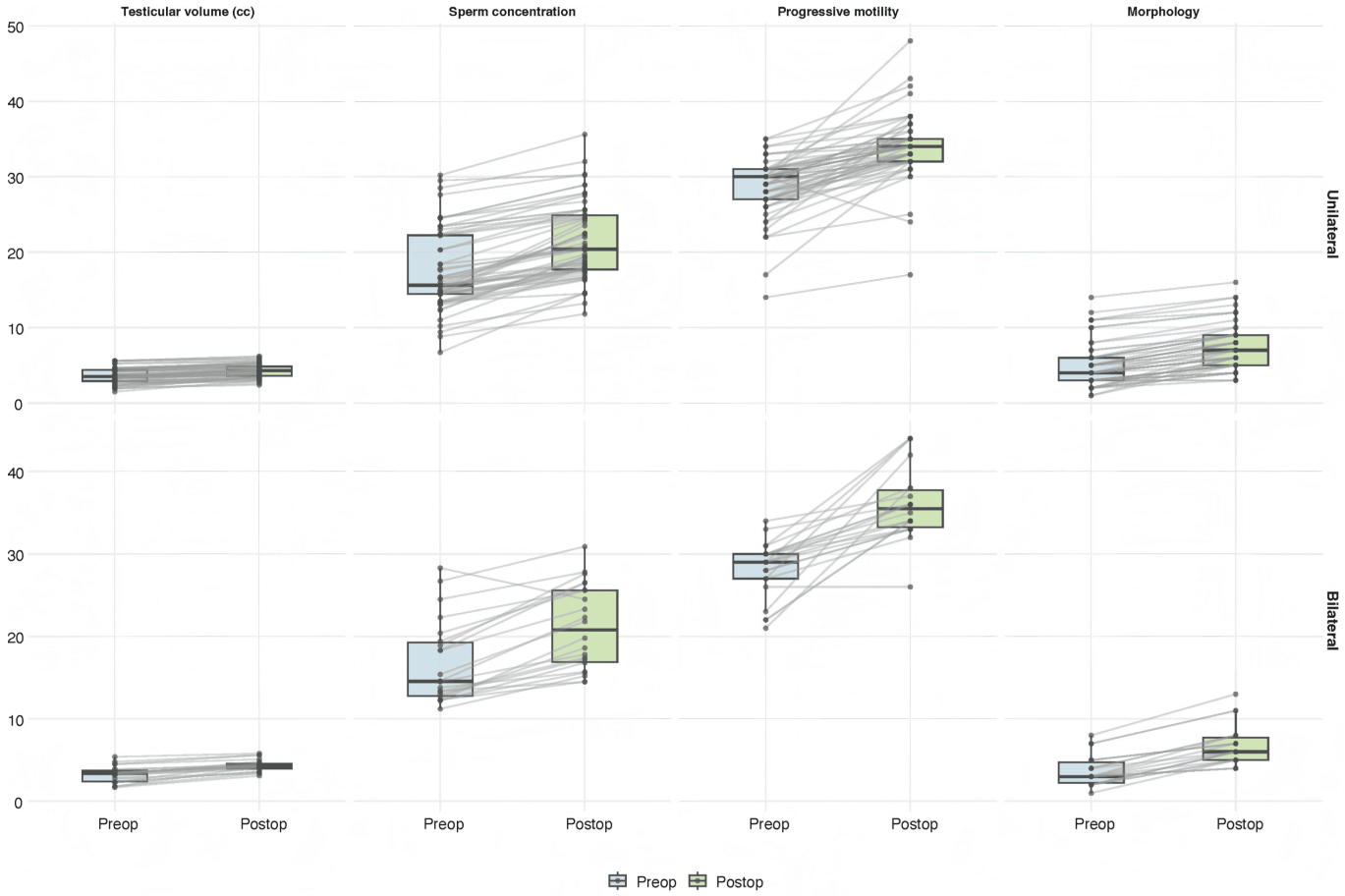

FIGURE 5. Postoperative semen parameter changes according to varicocele laterality.

TABLE 4. Baseline clinical characteristics and postoperative recurrence.

Variable Category	n	%
Scrotal pain		
No	41	50.6
Yes	40	49.4
Testicular atrophy		
No	68	84.0
Yes	13	16.0
Varicocele recurrence		
No	67	82.7
Yes	14	17.3

subinguinal varicocelectomy remains the gold standard treatment. However, expanding indications such as hypogonadism and assisted reproduction remain controversial [15].

This retrospective study suggests that varicocelectomy may be associated with favorable changes in semen parameters, testosterone levels, selected sexual function-related measures, and psychological well-being. However, the magnitude of improvement was not uniform across all endpoints, and some statistically significant findings appeared modest at the cohort level. Accordingly, these findings should be interpreted as supportive but not definitive evidence that varicocele may affect hormonal, sexual, and psychological domains beyond fertility alone.

We observed a modest but significant rise in IIEF-5 scores and an increase in normal nocturnal erections postoperatively. These findings are supported by the pathophysiological understanding that varicoceles disrupt testicular homeostasis through increased temperature, oxidative stress, and hypoxia, leading to impaired Leydig cell function and reduced testosterone production [16], which may contribute to hypogonadism and subsequent erectile dysfunction [17]. Surgical correction may restore venous drainage, which could contribute to improvements in endogenous testosterone secretion. In our cohort, postoperative testosterone increased by approximately 1.5 ng/mL, a change consistent with previous meta-analyses reporting a mean increase of 100–120 ng/dL after repair, as demonstrated in large meta-analyses evaluating endocrine outcomes following varicocele repair [18]. Najari *et al.* [4] further demonstrated that varicocelectomy improved patient-reported erectile function in 44% and ejaculatory function in 53% of men, corroborating our findings of enhanced erectile performance and libido. Consistent with previous reports by Zohdy *et al.* [19], which suggested that patients with low baseline testosterone or mild erectile dysfunction may benefit most from intervention; our study indicates that even patients with more severe baseline impairment (such as those with bilateral disease and lower testosterone levels) achieves meaningful postoperative recovery, particularly in semen quality and hormonal status [19]. Nevertheless, because the overall median IIEF-5 score changed only minimally in the full cohort, these findings should not be interpreted as evidence of a large universal clinical effect. Rather, the benefit appears more likely to be concentrated among patients with baseline erectile dysfunction.

Despite a relatively high mean baseline IIEF-5 score in the overall cohort, nearly one quarter of patients had clinically relevant erectile dysfunction at baseline. Importantly, patients with baseline erectile dysfunction were observed to have substantial and clinically meaningful improvements in erectile function following varicocelectomy, whereas those without erectile dysfunction showed minimal change. These findings suggest that the beneficial effects of varicocelectomy on erectile function are primarily driven by patients with preexisting dysfunction, thereby explaining the modest change observed at the cohort level.

In our study, a significant improvement was observed in both IELT and the PET scores following varicocele treatment. These findings suggest that varicocelectomy may be associated with beneficial effects not only on fertility outcomes but also on sexual function, particularly ejaculatory control and patient-reported satisfaction. The underlying pathophysiological mechanisms may involve the reduction of testicular hypoxia, oxidative stress, and venous stasis [20], which are known to negatively influence Leydig cell function and intratesticular testosterone levels. Restoration of normal testicular hemodynamics may improve androgen production [19] and peripheral neurotransmission, thereby contributing to enhanced ejaculatory latency and sexual satisfaction [21]. Our results support the hypothesis that varicocele repair could provide dual benefits by improving both reproductive and sexual health parameters, which is consistent with previous reports demonstrating similar associations between varicocelectomy and sexual function improvement [22]. Similarly, although paired statistical differences were observed for IELT, the absence of a clear shift in median values suggests that the clinical magnitude of this change may be limited at the overall cohort level. Therefore, these findings should be interpreted cautiously and should not be overstated. Furthermore, while baseline depressive symptoms were, on average, in the mild range, a substantial proportion of patients exhibited clinically relevant depressive symptom burden, with nearly two-thirds meeting the BDI $\geq$14 threshold. Importantly, postoperative improvements were not only statistically significant but also clinically meaningful, as 61.7% of patients achieved a $\geq$5-point reduction in BDI score. The magnitude of improvement was greatest in those with higher baseline depressive symptom burden, suggesting that the psychological benefits of varicocelectomy may be most apparent in patients with preexisting symptoms.

All conventional semen parameters volume, sperm concentration, motility, and morphology showed robust improvements. These findings align with the largest meta-analyses, including the systematic review by Cannarella *et al.* [23], and Fallara *et al.* [22], which confirmed significant gains across nearly all semen parameters following varicocelectomy. Particularly notable in our cohort was the ~55% relative increase in normal morphology, a parameter often difficult to improve. These biological effects can be explained by mechanisms such as reduced oxidative stress, restored thermoregulation, and enhanced Sertoli cell function. Clinically, such changes may translate into improved fertility potential [22], even though pregnancy outcomes were not directly measured. Importantly, improvements were observed across all varicocele grades, consistent with the conclusions of Asafu-Adjei *et al.* [24], who reported that postoperative semen improvement occurs regardless of varicocele grade, though higher grades may show larger absolute gains.

Bilateral varicocele patients in our study had lower baseline testosterone and worse sexual function, consistent with more severe Leydig cell impairment. Nevertheless, they demonstrated substantial postoperative gains in semen parameters, particularly motility, highlighting that even men with extensive disease can benefit significantly from surgical repair. Shomarufov *et al.* [25] similarly emphasized that clinical grade alone has limited predictive value for postoperative outcomes, reinforcing the notion that treatment decisions should be based on symptoms, semen profile, and hormonal status rather than

varicocele grade in isolation [25]. Notably, improvements were observed across all clinical grades and both laterality groups, reinforcing that clinical severity alone is not a reliable predictor of postoperative functional or reproductive outcomes.

Nearly half of our patients presented with scrotal pain, which was reported to improve in most patients after surgery, confirming pain relief as a valid surgical indication. This finding is consistent with previous reports, where pain improvement rates following varicocelectomy have been reported between 70–90% [26, 27]. Testicular atrophy did not deteriorate during follow-up, suggesting that repair can help prevent further deterioration. This supports the idea that correction of venous reflux and improving testicular blood flow can help mitigate or potentially reverse the effects of varicocele on testicular size. Previous studies have also reported stabilisation or recovery of testicular size after varicocelectomy, supporting early surgery to preserve function [28, 29]. Psychological outcomes also improved substantially, as indicated by a shift in mean BDI scores from the mild to the minimal range, reflecting a reduction in depressive and anxiety symptoms. This improvement can be related to the combined effects of hormonal recovery, resolution of scrotal pain, and mitigation of infertility-related psychological distress. Collectively, these findings highlight the holistic benefits of varicocelectomy, extending beyond laboratory and reproductive parameters to encompass overall quality of life [30].

Our recurrence rate was 17.3%, mostly subclinical, with only 2.5% of patients requiring repeat intervention. This is comparable to the recurrence rates reported in the literature, which range between 10–20% depending on surgical technique [31, 32]. Importantly, no major postoperative complications were encountered, further supporting the safety of varicocelectomy in our cohort. We acknowledge that this rate is higher than those typically achieved with subinguinal varicocelectomy. The higher recurrence observed in our cohort is attributable to the open inguinal + subinguinal technique employed, which lacks the optical magnification necessary to identify and preserve small lymphatics or ligate minor venous collaterals.

Therefore, our findings regarding recurrence and complications should be interpreted within the context of the open surgical approach and may not be generalizable to centers utilizing microsurgical techniques. Nevertheless, reporting outcomes from this conventional approach remains relevant, as open repair is still widely practiced in many resource-constrained settings. However, open inguinal repair remains a widely practiced technique in many resource-constrained settings globally. Therefore, reporting outcomes from this conventional approach provides valuable “real-world” data regarding its efficacy in improving sexual and hormonal parameters, even if recurrence risks are higher compared to microsurgery.

These findings should be interpreted with caution because of the retrospective before–after design and, most importantly, the absence of a non-surgical control group. As a result, causal inference is limited, and the observed improvements in subjective and psychosexual outcomes may partly reflect placebo effects, regression to the mean, natural temporal variation, or increased patient attention during follow-up rather than the isolated effect of surgery alone. Another limitation is the reliance on self-reported measures for several key endpoints, including IELT, libido score, and NPT grade. Given the unblinded nature of the intervention, these outcomes may have been influenced by recall bias, reporting bias, social desirability bias, and expectancy effects.

A considerable proportion of patients (57 out of 138) were excluded due to incomplete data or loss to follow-up. This may have resulted in the preferential inclusion of patients with more complete datasets or better follow-up compliance, potentially influencing the observed outcomes. Therefore, the findings of this study should be interpreted with caution in this context.

5. Conclusions

In this retrospective cohort of symptomatic men, varicocelectomy was associated with favorable changes in semen parameters, testosterone levels, and several sexual and psychological outcome measures at 6 months. However, the magnitude of change in some endpoints, particularly IIEF-5 and IELT at the cohort level, appeared modest. Given the lack of a control group and the subjective nature of several assessments, these findings should be interpreted as associative rather than causal. Prospective controlled studies are needed to better define the clinical relevance of these observations.

AVAILABILITY OF DATA AND MATERIALS

The datasets generated and/or analyzed during the current study are not publicly available due to institutional data protection policies and patient privacy regulations but are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

HT and SNG—designed the research study. HT and ÖFM—performed data collection. HT, OK and SÖ—analyzed and interpreted the data. HT, EMY and SNG—drafted the manuscript. YA—critically revised the manuscript for important intellectual content and supervised the study. All authors contributed to editorial changes in the manuscript and read and approved the final version.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the İzmir Kâtip Çelebi University Health Research Ethics Board (Approval No. 0075, 13 February 2025), and retrospective studies using anonymized patient data do not require individual informed consent according to institutional ethics committee regulations.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://....

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