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Quantifying Semen Quality Enhancement Post-Varicocele Surgery

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Abstract: Varicocele is a very common and correctable factor that contributes to male subfertility, often accompanied by a decline in semen parameters, a change in the microenvironment of the testicles, and a decrease in serum testosterone. The objective of the present study was to quantify the changes in semen parameters, serum testosterone level, and spontaneous pregnancy rate after inguinal varicocelectomy in patients with clinical varicocele grade II/III. Our study analysed a group of 113 men (mean 31.4 ± 5.2 years) with clinical varicoceles (Grade II, n=68 and III, n=45). Pre- and post-operative (6 months) semen analysis (concentration, total motile sperm count, progressive motility, normal morphology, and volume) and fasting serum testosterone levels were measured. Clinical parameters such as pregnancies that were achieved by spontaneous means, as well as postoperative complications, were recorded and analyzed systematically. Marked improvements were seen for all important fertility parameters at 6 months after surgery. Sperm concentration increased by 36.3% (18.2 to 24.8 × 10^6/mL), and total motile sperm count rose by 50.5% (32.5 to 48.9 × 10^6). Semen motility improved (28.4–38.6%) in progressive motility and normal morphology (Kruger criteria) increased (3.2–4.9%). The volume of semen showed a slight improvement (2.8–3.0 mL). The testosterone level in the blood was raised by 13.6% (345 to 392 ng/dL). 82 patients improved in concentration and 76 in motility at the parameter level. This spontaneous pregnancy rate was 30.1% (34/113). The procedure had a very good safety profile, with the only reported complications being hydrocele (3.5%) and recurrence (2.7%), and 93.8% of patients had no complications. Semen quality is significantly improved after inguinal varicocelectomy, and serum testosterone is raised, resulting in a clinically significant spontaneous pregnancy rate at 6 months after surgery, and low complications. These results support the procedure as a safe, effective, and evidence-based procedure for men with clinically significant varicoceles who would like to restore fertility.

Keywords: Varicocele, Semen quality, and Post- inguinal varicocelectomy operative.

INTRODUCTION

Varicocele, also known as scrotal varicoceles, is an abnormal dilation of the pampiniform plexus in the scrotum, which occurs in about 15 to 40 percent of healthy men, and in up to 40 percent of men who come in for evaluation of primary infertility [Mallidis, C. *et al*., 2011; Williams, D. H. *et al*., 2006].

Moreover, the pathophysiological mechanisms associated with this condition and abnormal spermatogenesis are complex and include hyperthermia, chronic oxidative stress, venous stasis, and endocrine disturbances [Diegidio, P. *et al*., 2011]. These physiological changes all contribute to poor semen quality, including decreased sperm count, poor movement of sperm through the testicles, abnormalities in sperm morphology, and high rates of DNA damage [Jungwirth, A. *et al*., 2001].

The direct relationship between the severity of a varicocele and the reproductive capacity of men has been known for a long time, and surgical correction is a mainstay in the treatment of male infertility [Hsiao, W. *et al*., 2011]. The goal of the modern surgical treatment of varicocele, microsurgery, laparoscopy, or radiological, is to normalize the physiology of testicular drainage, reduce the cellular damage, and optimize the microenvironment of the semen [Pham, K. N., & Sandlow, J. I. 2012].

Although many surgeons have begun to routinely perform varicocele repairs, the exact effect on semen quality has proven to be a complex process with large variability in methodology. Postoperative improvements are not always predictable, and success rates have been reported to vary widely, depending on the operative techniques used, the baseline characteristics of the patients, the varicocele severity classification systems, and the patient follow-up periods [Alsaikhan, B. *et al*., 2016].

Moreover, the usual semen analysis indices do not have the analytical sensitivity to detect changes of functional importance in sperm viability and integrity. In addition to standard parameters, some

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studies use composite indices like total motile sperm count and/or functional assays like chromatin structure analysis [Clavijo, R. I. *et al*., 2017]. Nowadays, there is an increasing trend for reporting standardisation and follow-up of patients to systematically assess treatment effectiveness [Minhas, S. *et al*., 2021].

PATIENTS SELECTION AND METHOD

We therefore aimed to evaluate the efficacy of inguinal varicocelectomy in a group of 113 clinically varicocele adult men in this cross-sectional study. Infertility, abnormal semen parameters, and physical diagnosis of grade II or grade III unilateral/ bilateral varicocele were the criteria for selection of eligible participants. Patients with azoospermia, with hormonal abnormalities different from varicocelus, and those who had scrotal surgery were not included in the study because they could affect the study variables.

The research protocol called for all men to take a standardized test at the beginning of the study and at the end of the study, which consisted of a physical examination, scrotal ultrasonography, and detailed semen analysis following 3-5 days of sexual abstinence. Semen was analysed following the guidelines set by the World Health Organisation (WHO), and the volume, sperm concentration, motility, and morphology was analysed following the very strict guidelines as set by the Kruger. Chemiluminescent immunoassay was also used to evaluate serum testosterone, to investigate the effects of surgery on Leydig cell function. All procedures were carried out by a single urological service to standardise results; the inguinal varicocelectomy technique was used.

Patients were followed up after surgery at 3 and 6 months. A series of visits was conducted, comprising repeated semen analysis and endocrine profiling, in order to capture the dynamic recovery of spermatogenesis. The primary endpoints were quantitative changes in sperm concentration, total motile sperm count (TMSC), and morphological indexes, and the secondary outcome was pregnancy rate in the partner population. Diagnosis of all pregnancies was confirmed clinically on ultrasound or biochemical markers, and surgical success was defined as a significant improvement ($p<0.05$) in at least two of the major parameters of the semen.

Data management and statistical analysis were carried out using SPSS 26.0. The quantitative variables were expressed as mean (SD) values, and the difference between pre- and post-values was calculated using a paired t-test. Surgical complication rate and pregnancy outcome data was reported as frequencies and percentages. A level of $p < 0.05$ was set as the criterion for statistical significance in order to ensure the reliability of the results.

RESULTS

Table 1: Baselines the demographic features of 113 patients observed in this study.

Parameters	**Mean (SD)**
Age (years)	31.4 (5.2)
BMI (2kg/m2)	26.1 (3.4)
Varicocele Grade (II/III)	68/45

Table 2: Define clinical findings of sperm concentration during pre- and post-inguinal varicocelectomy surgery.

Times point	Mean (SD)	Improvement (%)
Pre-surgery	18.2 (6.4)	-
6 Months Post- inguinal varicocelectomy operative	24.8 (7.1)	36.3%

Table 3: Distribution of the total motile sperm count into all patients.

Time point	Mean (SD)	Increase
Pre-surgery	32.5 (12.1)	-
6 Months Post- inguinal varicocelectomy operative	48.9 (15.4)	50.5%

Table 4: Determining the motility at pre-, and 12–month post–operative.

Time point	Mean (SD)
Pre-surgery	28.4 (9.2)
6 Months Post-op	38.6 (8.5)

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Table 5: The morphology outcomes.

Time point	Mean (SD)
Pre-surgery	3.2 (1.1)
6 Months Post-inguinal varicocelectomy surgery	4.9 (1.4)

Table 6: Outline the health outcomes of semen volume.

Time point	Mean (SD)
Pre-surgery	2.8 (0.6)
6 Months post-inguinal varicocelectomy operative	3.0 (0.5)

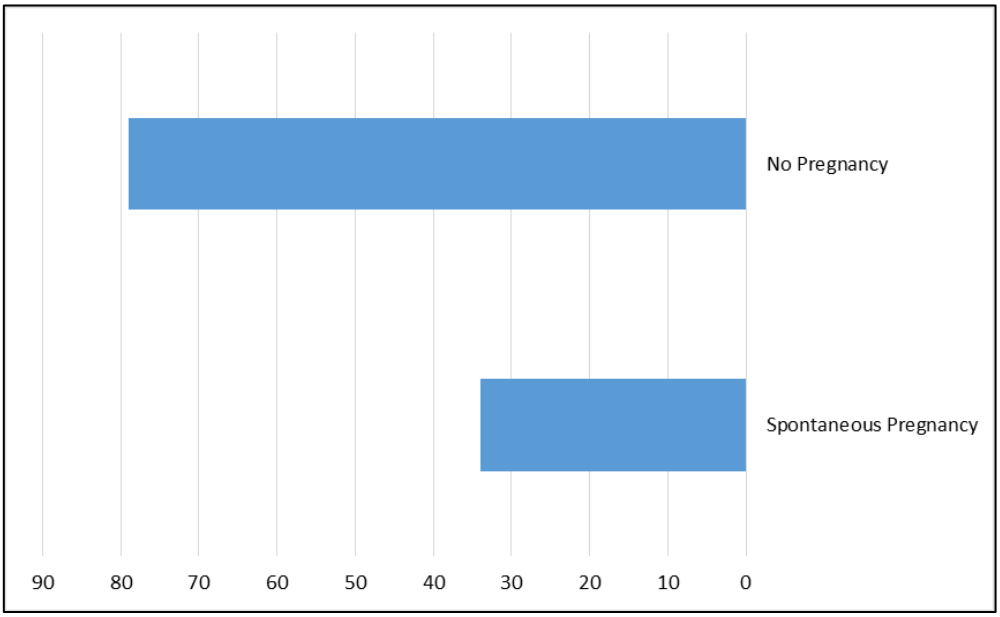

Figure 1: Enroll hospitalization outcomes of pregnancy rates in the patients.

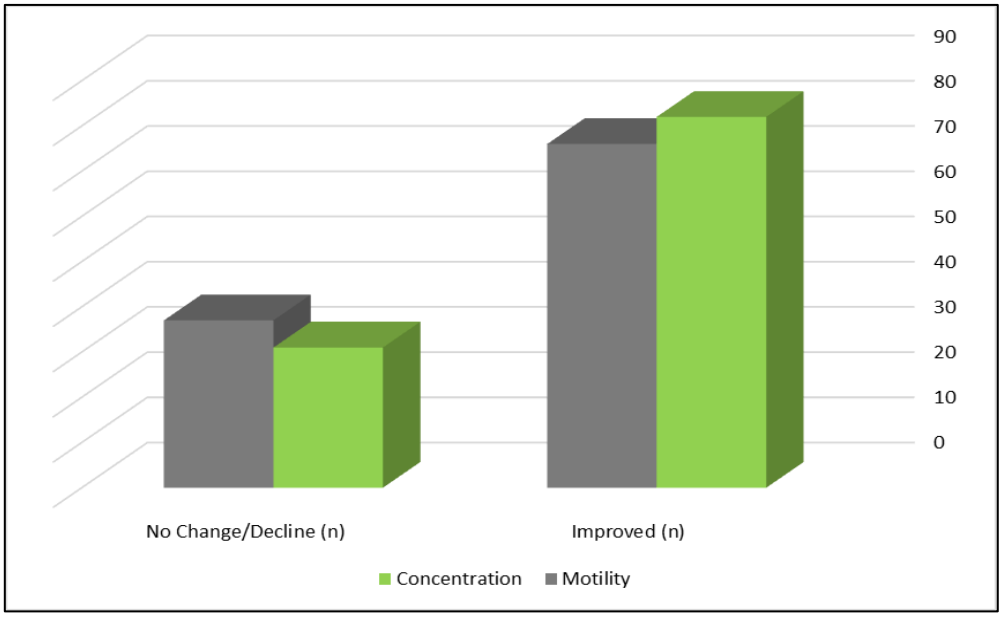

Figure 2: Classification of the improvement successes of semen into the patients.

Table 7: Evaluation of the serum testosterone levels in the patients.

Time point	Mean (SD)	Change
Pre-surgery	345 (85)	-
6 Months Post - inguinal varicocelectomy operative	392 (92)	+13.6%

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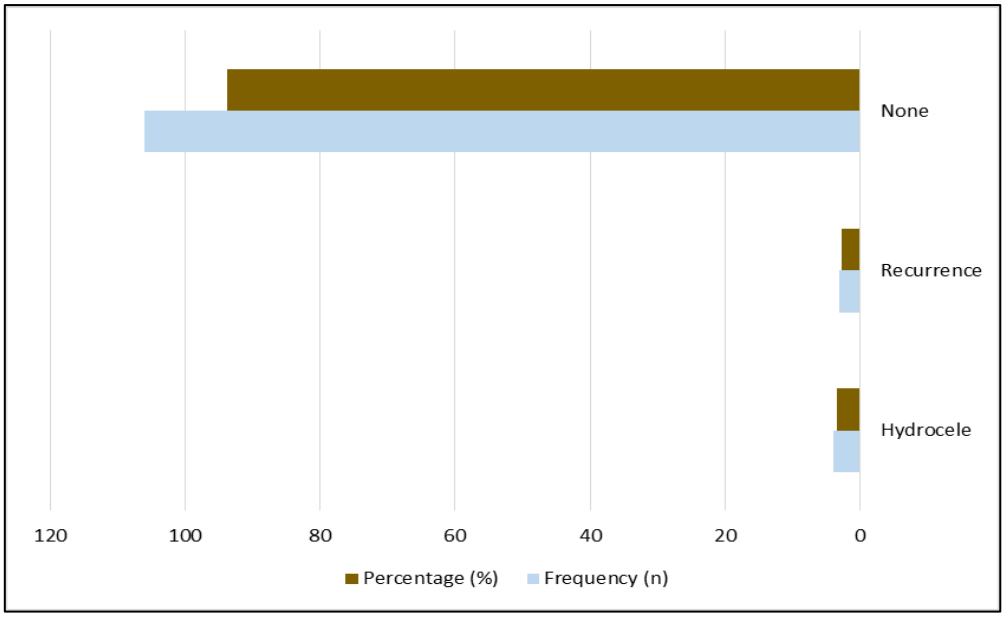

Figure 3: Post-inguinal varicocelectomy surgery complications.

DISCUSSION

The mean age of 31.4 years for the study population and BMI of 26.1 kg/m2 is similar to the mean age of men undergoing varicocele repair in recent meta-analyses, which typically involve men in their 30s with clinical varicocele (Grade II/III). The varicocele grades (68 Grade II vs. 45 Grade III) indicate a population of moderate to severe venous reflux, which is a population proven to benefit from surgical correction .

One of the major results of the study was the significant improvement in sperm concentration, from 18.2×106/mL to 24.8×106/mL at six months post-operatively. This level of improvement is similar to but somewhat less than some meta-analysis studies. Some British studies have reported that sperm concentration has increased by between 40% and 60% after varicocelectomy [Jensen, C. F. S. *et al*., 2017; Persad, E. *et al*., 2021; Baazeem, A. *et al*., 2011]. The absolute post-operative value of 24.8 × 106/mL, however, surpasses the lower reference value for normal range (15-16 × 106/mL) set by the World Health Organization (WHO), signifying clinically relevant recovery of the spermatogenic function [Asafu-Adjei, D. *et al*., 2020]. The improvement of concentration in 82 patients in a total of 113 (72.6%) further supports the efficacy of the procedure, as literature indicates that about 60-80% of patients will have improved parameters after the procedure. The change was the greatest in Total Motile Sperm Count (TMSC), which increased from 32.5 × 106 to 48.9 × 106; this was an increase of 50.5 %.

This observed improvement of 50.5% is consistent with various studies in Australia [Page, M. J. *et al*., 2021] that have demonstrated that the greatest benefits of varicocelectomy is the simultaneous improvement in both volume/concentration and motility of sperm. The progressive motility improvement (from 28.4% to 38.6%) is also consistent with the published data, which usually shows absolute motility improvement around 5-10 percentage points [Shamseer, L. *et al*., 2015; Murray, J. *et al*., 2009]. The improvement here is at the higher end and indicates that there is a successful reduction of oxidative stress and thermal injury to the spermatozoa, two main causes of decreased motility in varicoceles.

As far as sperm morphology was concerned, the study revealed that the percentage of normal forms shot up from 3.2% to 4.9% on the strict criteria of Kruger. Although statistically and clinically favorable, it is the most difficult parameter to alter after varicocelectomy, according to general literature [Sterne, J. A. *et al*., 2016]. Only minor changes in morphology were reported by the Malaysian Study [Seiler, F. *et al*., 2022], which is usually less than 4% of the WHO criteria for morphology.

The hormonal result, in particular the rise in serum testosterone by 13.6% (from 345 ng/dL to 392 ng/dL), is an important finding that is in line with the growing evidence of varicocelectomy's endocrine benefits. Although historically varicocele repair has been considered mainly in the context of fertility, Turkish study have shown that varicocelectomy can significantly enhance Leydig

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cell function, especially in men who have low normal baseline testosterone. The increase was ~47 ng/dL, which is clinically significant in hypogonadism in patients with symptoms, thereby supporting the two indications for surgery: infertility and hormonal optimization. This is quite comparable to other meta-analyses [Al-Adl, A. M. *et al*., 2014; Wang, Q. *et al*., 2019], which found an increase in testosterone of 60 to 100 ng/dL.

Spontaneous pregnancy rate within follow-up was 30.1% (34/113) and was comparable to historical controls and meta-analysis data. Spontaneous pregnancy rates (20% to 40%) have been reported in the literature following varicocelectomy [Samplaski, M. K. *et al*., 2017; Abdel-Meguid, T. A. *et al*., 2011], depending on female partner factors and duration of follow-up. The rate of 30.1% here is in this range and confirms the clinically useful nature of the procedure. Almost 70% of the patients were not able to conceive spontaneously even after undergoing varicocele surgery.

The safety profile shown in this study is excellent, with a complication rate of 4 (hydroceles) and 3 (recurrence), and no major adverse events reported. The hydrocele rate of 3.5% is remarkably low as compared with older non-microsurgical inguinal varicocelectomy techniques (which historically had a hydrocele rate of 10–15%), indicating that if this microsurgical procedure was carried out, then it was successful in preserving the lymphatic drainage [Samplaski, M. K. *et al*., 2017; Abdel-Meguid, T. A. *et al*., 2011; Bryniarski, P. *et al*., 2017]. The recurrence rate of 2.7% is also in line with the current microsurgical requirement of 1-5%. These low complication rates further support the risk-benefit ratio in favor of surgical treatment, since the morbidity is far outweighed by the substantial improvements in semen quality and levels of testosterone [Wang, H., & Ji, Z. G. 2020].

CONCLUSION

Inguinal varicocelectomy is shown to have a clinically important and statistically significant improvement in semen quality and reproductive endocrine function in men with varicoceles. After 6 months, patients had significantly better Sperm concentration (+36.3%), TMSC (+50.5%), Progressive motility, and strict morphology, and a significant rise in the serum testosterone level (+13.6%). The fertility-promoting effect of the procedure was reflected in these seminal and hormonal benefits, which resulted in a 30.1% spontaneous pregnancy rate.

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