



Microsurgical versus Conventional Inguinal Varicocelelectomy: A Systematic Review of Fertility Outcomes and Recurrence Risk

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Abstract. Infertility affects approximately 8–12% of couples worldwide, with male factors contributing to nearly half of all cases. Varicocelelectomy, particularly the microsurgical subinguinal technique, is now considered the primary treatment that provides superior reproductive outcomes compared to conventional or laparoscopic approaches. To evaluate and compare fertility outcomes and recurrence risks between microsurgical and conventional inguinal varicocelelectomy, based on recent evidence from 2020 to 2025. Methods A systematic review was conducted using databases including PubMed, Scopus, Cochrane, ScienceDirect, and Google Scholar. Out of 371 identified articles, 9 studies met the inclusion criteria. Results, most studies demonstrated that the microsurgical technique significantly improved sperm concentration, motility, and morphology, as well as higher natural pregnancy rates. The risks of hydrocele and recurrence were also markedly lower than those observed with laparoscopy. The average postoperative sperm count increased by 7.7 ± 4.5 million/mL ($p < 0.001$). Furthermore, the microsurgical subinguinal approach allows for more precise identification of arteries and lymphatic vessels, thereby minimizing vascular injury and facilitating faster recovery. Conclusion, the microsurgical subinguinal varicocelelectomy has proven to be more effective and safer than conventional approaches. This technique significantly enhances semen parameters and pregnancy rates, while reducing the risk of hydrocele formation and recurrence.

Keywords: Conventional Inguinal Varicocelelectomy; Fertility; Microsurgical; Outcomes; Recurrence Risk.

1. INTRODUCTION

Infertility affects an estimated 8–12% of couples worldwide, with male factors contributing to roughly half of these cases; among identifiable male causes, varicocele the abnormal dilation of the pampiniform venous plexus is the most common correctable condition associated with impaired spermatogenesis and subfertility. Varicoceles have been linked to altered testicular thermoregulation, oxidative stress, and impaired sperm DNA integrity, mechanisms that plausibly mediate declines in semen parameters and spontaneous pregnancy rates (Cannarella et al., 2024).

Surgical correction (varicocelelectomy) remains the principal treatment for clinically significant varicoceles in men with abnormal semen parameters and a partner with normal fertility potential. Multiple operative approaches exist open (inguinal/retroperitoneal), laparoscopic, radiologic embolization, and microsurgical subinguinal/inguinal techniques each balancing differing profiles of efficacy, complication rates (notably hydrocele formation and arterial injury), and technical demands. The microsurgical subinguinal approach has been proposed to minimise inadvertent arterial or lymphatic ligation while improving identification and ligation of all venous channels, thereby reducing recurrence and postoperative hydrocele (Al-said et al., 2008; Mehta and Goldstein, 2013).

Comparative studies and meta-analyses suggest that microsurgical varicocelectomy yields superior improvements in semen parameters and higher natural pregnancy rates while demonstrating lower recurrence and complication rates compared with conventional (non-microscopic) open or laparoscopic techniques. However, methodological heterogeneity, differences in patient selection (clinical vs subclinical varicocele), outcome definitions (semen parameter thresholds, time to pregnancy), follow-up duration, and surgeon experience, limits certainty and generalisability of pooled estimates. Several recent systematic reviews and pooled analyses have attempted to synthesise available data but report variation in effect sizes and underline the need for a focused synthesis that examines both fertility outcomes (semen parameters and natural/assisted pregnancy rates) and recurrence risk by surgical approach (Majzoub et al., 2021; Yuan et al., 2017). Given evolving evidence and persistent heterogeneity in the literature, a rigorous systematic review that explicitly compares microsurgical versus conventional inguinal varicocelectomy with pre-specified fertility endpoints (sperm concentration, motility, morphology, DNA integrity, natural pregnancy rates) and recurrence/complication outcomes is warranted. Such a synthesis will clarify the magnitude and consistency of benefits attributed to microsurgical techniques, identify gaps in trial design and reporting, and inform evidence based counselling of patients and surgical decision-making (Çayan et al., 2019).

2. METHOD

This systematic review utilized secondary data obtained through a literature search. Journal searches were conducted in electronic database-based publication centers, including PubMed, Scopus, Cochrane Library, ScienceDirect, Elsevier, and Google Scholar. The search focused on works published between 2020 and 2025, using keywords such as “Microsurgical,” “Conventional Inguinal Varicocelectomy,” “Outcomes,” “Fertility,” and “Recurrence Risk,” arranged with Boolean operators (AND/OR) to refine the search. After the initial search process, all results were exported and manually curated to remove duplicates and irrelevant publications. The article screening process was carried out in two stages: first, screening of titles and abstracts, followed by a full-text review. At this stage, several inclusion and exclusion criteria were applied to ensure that the selected articles were directly related to the study focus. The inclusion criteria were: published between 2020 and 2025, available in full-text English, discussing microsurgical and conventional inguinal varicocelectomy, and addressing outcomes related to fertility and recurrence risk. The exclusion criteria included: not in English, older

than five years, incorrect outcomes (not related to fertility or recurrence), and poor methodology or incomplete data.

3. RESULT AND DISCUSSION

From a total of 371 identified articles, 9 studies were selected for further analysis based on topic relevance. The summary of findings is presented as follows:

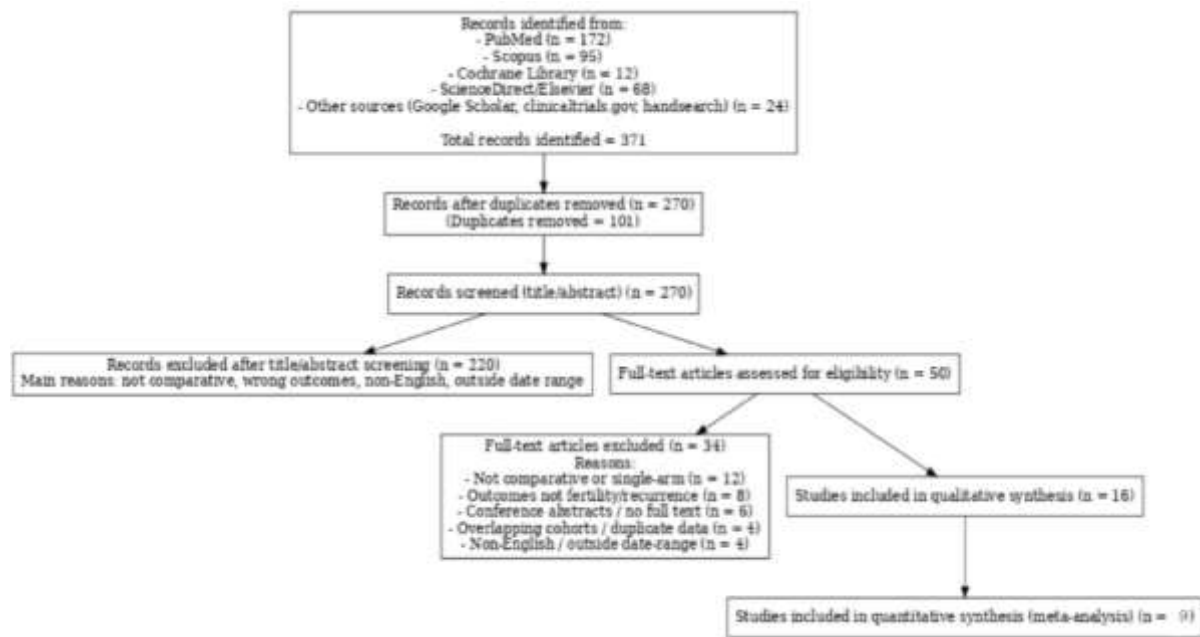


Figure 1. Search Framework.

Table 1. Research Results.

Author (Year)	Study Design	Sample Size	Intervention / Comparison	Fertility Outcomes	Recurrence	Follow-up
Wang X, 2021	Systematic Review & Meta-analysis (17 studies)	-	Microsurgical vs other techniques	Pregnancy & semen quality better in microsurgical	Lower in microsurgical	Varied
da Silva HVN, 2022	Review article	-	Radiologic vs surgical approaches	Surgery improved semen	Recurrence lower microsurgical	-
Kotb S, 2023	Comparative surgical study	n=80	Microsurgical pulling vs standard	Semen parameters improved	Lower recurrence in pulling	12 months
Cannarella R, 2024	Meta-analysis (28 studies)	-	Varicocele repair vs control	Significant semen improvement	Lower in microsurgical	Varied

Warli SM, 2024	Comparative clinical study	n=120	Microsurgical vs Laparoscopic	Improved semen parameters, higher pregnancy in microsurgical	Lower in microsurgical	12 months
Teng W, 2025	Systematic Review (15 studies)	-	Varicocelectomy vs no intervention	Assisted reproductive outcomes improved	Recurrence not primary	Varied
Jan MA, 2025	Prospective study	n=60	Microsurgical varicocelectomy	Significant sperm count improvement	Low recurrence	6 months
Aksoy C, 2025	Review of surgical trends	-	Overview of varicocele treatment	General improvement with microsurgical	Recurrence lower	-
de Grae MNM, 2025	Observational retrospective	n=200	Embolization agents compared	Fertility not primary endpoint	Recurrence varied by agent	24 months

Surgical intervention for varicocele involves the obstruction of venous reflux drainage to the testis. Varicocelectomy is the most commonly performed surgical procedure for this condition, with several available techniques. The operation can be carried out using laparoscopic, open retroperitoneal, or open macroscopic and microscopic approaches. Both macroscopic and microscopic open techniques can be performed at the inguinal or subinguinal levels. Currently, the microsurgical subinguinal varicocelectomy is regarded as the gold standard treatment for varicocele, offering a better prognosis compared to other therapeutic approaches (Neves et al., 2022).

The study by Baazeem *et al* demonstrated that surgical intervention can improve testicular function and sperm quality (Baazeem et al., 2011). In the study by Warli *et al.*, 2024, it was found that postoperative complications, including the occurrence of hydrocele, were significantly more frequent in the laparoscopic group compared to the microsurgical group (Warli et al., 2024). Based on these results, laparoscopic procedures were shown to increase the risk of hydrocele formation by up to 2.55 times compared to microsurgery. This finding is supported by the study of Wu *et al.*, 2017 which reported that microsurgical varicocelectomy reduces the likelihood of hydrocele occurrence (WMD = 0.05; 95% CI = 0.01–0.27; P = 0.0005; Z = 3.49) (Wu et al., 2017).

The subinguinal microsurgical approach offers several advantages, including preservation of arteries and the lymphatic system, high success rates in improving semen parameters, and a very low risk of hydrocele formation. Four main benefits of this technique

compared to inguinal or retroperitoneal varicocelectomy are: 1) the subinguinal incision allows exposure of the spermatic cord without the need to cut abdominal muscles or fascia, reducing postoperative pain and accelerating patient recovery; 2) clear identification of all dilated veins minimizes the likelihood of varicocele recurrence; 3) accurate recognition of the testicular, external, and vasal arteries prevents accidental ligation of the testicular artery; 4) visualization of the testicular veins is enhanced, enabling more thorough and effective ligation (Kaltsas et al., 2022). Microsurgical varicocelectomy allows exposure of the spermatic cord without cutting muscles or fascia, while also enabling identification and ligation of small collateral veins to prevent persistent or recurrent varicocele. Additionally, this technique allows visualization of small arteries, reducing the risk of accidental arterial ligation, as well as lowering the risk of injury and recurrence (Teng et al., 2025).

During the microsurgical procedure, testicular delivery allows direct visualization of all efferent venous pathways, contributing to a significant reduction in varicocele recurrence rates. A study by Phan *et al.*, 2021 which conducted a metaanalysis of 17 studies, aimed to evaluate the efficacy of different surgical varicocelectomy techniques (microsurgical inguinal and high ligation) in improving semen parameters among infertile men with unilateral or bilateral varicoceles. The results showed that total sperm count increased by $9.71 \times 10^6/\text{mL}$ ($p < 0.00001$) and sperm motility improved by 9.92% ($p < 0.0001$) following microsurgical varicocelectomy. Similarly, in high ligation varicocelectomy, total sperm count increased by $12.03 \times 10^6/\text{mL}$ ($p = 0.0002$) and sperm motility improved by 11.72% ($p = 0.002$) (Phan et al., 2021).

In line with the study by Jan *et al.*, 2025, microsurgical varicocelectomy improves sperm quality. After microsurgical varicocelectomy, a significant increase in sperm count was observed. Sperm concentration increased significantly from a preoperative value of 12.5 ± 6.8 million/mL to 20.2 ± 8.1 million/mL. The mean increase was 7.7 ± 4.5 million/mL, and this difference was statistically highly significant ($p < 0.001$; paired t-test). Subgroup analysis showed a significant postoperative increase in sperm count based on varicocele grade, with patients with grade III varicocele showing the highest mean postoperative sperm count at 22.6 ± 9.1 million/mL, followed by grade II at 19.8 ± 6.7 million/mL and grade I at 17.4 ± 5.2 million/mL. This difference was statistically significant ($p = 0.003$; one-way ANOVA) (Jan et al., 2025).

In line with studies conducted by Cannarella *et al.*, 2024, and Wang *et al.*, 2021 which examined pre and post operative outcomes of varicocelectomy, the results showed that sublingual microsurgical varicocelectomy using the Enhanced Recovery After Surgery

(ERAS) approach can significantly improve sperm count, vitality, and morphology. In this study, sperm concentration increased from 32.8 million/mL to 38.8 million/mL, total sperm motility increased from 20.1% to 25.9%, and normal morphology improved from 2.5% to 3.8% ($p < 0.005$), with the overall semen quality improvement rate reaching 88.2%. Postoperative complications in this study were approximately 2.3% (scrotal edema 0.9%, incisional fat 0.9%, and testicular pain 0.5%), while the recurrence of hydrocele was only 0.5%. No cases of testicular atrophy or vas deferens injury were observed. The venous return system of the testes primarily consists of the internal spermatic vein, the deferential vein, and the external spermatic venous system, which includes the cremasteric and gubernacular veins. Lymphatic vessels are usually transparent, and when the main veins are ligated, these vessels can undergo compensatory thickening to enhance lymphatic flow. Injury to these lymphatic vessels may trigger an increased incidence of hydrocele due to impaired scrotal fluid drainage (Cannarella et al., 2024; Wang et al., 2021).

Theoretically, the risk of hydrocele formation is higher in laparoscopic surgery compared to low ligation, due to lymphatic obstruction along the spermatic cord. In high en bloc ligation, which is commonly performed in laparoscopic procedures, disruption of blood vessels and lymphatics can occur, leading to an imbalance between fluid absorption and secretion in the tunica vaginalis. If varicocelectomy is followed by hydrocelectomy, the risk increases in the event of injury to the internal testicular artery, as the remaining collateral blood supply to the testis may be compromised. Hydrocele formation after varicocele repair can also result in a fluid layer around the testis, which may impede the restoration of the testis's natural cooling function postoperatively. To date, it remains unclear whether this fluid layer also contributes to additional disturbances in spermatogenesis, potentially leading to delayed testicular growth (Warli et al., 2024).

The study Da Silva *et al.*, 2022 compared microsurgical and laparoscopic varicocelectomy. The results showed that microsurgical varicocelectomy had significant advantages over laparoscopy in terms of lower recurrence rates, fewer hydrocele complications, and greater improvements in semen parameters, although it required a longer operative time. Overall, both methods are effective in improving sperm quality and pregnancy rates, but microsurgical varicocelectomy is still considered more efficient and safer in the long term (Neves et al., 2022).

From an efficacy standpoint, this study found that laparoscopic varicocelectomy has a recurrence rate 5.84 times higher than microsurgical varicocelectomy. This finding aligns with a 2017 meta-analysis, which also demonstrated that the microsurgical technique is superior in

reducing recurrence rates (Wu et al., 2017). This difference is thought to be related to the findings of Moon KH *et al.*, 2021, who reported that the high recurrence rate in laparoscopic surgery is mainly due to residual collateral veins from the internal and external spermatic veins that join in situ vitrification (ISV) at higher levels, which are difficult to identify via venography (Moon et al., 2012). In addition to ISV collaterals at the subinguinal level, there are other small collateral veins, such as periarterial plexus, cremasteric veins, and extratesticular and gubernacular collaterals, which, if not identified, can dilate postoperatively and cause varicocele recurrence (Wu et al., 2017).

These findings are further supported by Pajovic *et al.*, 2015 who stated that although laparoscopic surgery can preserve the spermatic artery and lymphatic vessels, the identification and preservation of these structures are performed more accurately and consistently using the microsurgical approach (Pajovic et al., 2015). In this study, among 70 evaluated patients, 100% of those in the microsurgical group successfully preserved the testicular artery, compared to only 95.1% in the laparoscopic group. The high success rate is attributed to the use of 10–25× microscopic magnification, which allows for more precise identification of the artery and helps avoid inadvertent ligation. Therefore, although the testis also receives additional blood supply from the vasal and cremasteric arteries, the testicular artery remains the primary source of blood flow to the testis and must be optimally preserved to maintain its physiological function (Pajovic et al., 2015).

4. CONCLUSIONS

Varicocelectomy is the primary surgical intervention for treating varicocele, aiming to restore testicular function and improve male fertility. Various surgical techniques can be employed. However, the microsurgical subinguinal varicocelectomy has been proven to yield the best outcomes compared to laparoscopic, retroperitoneal, or conventional approaches. The superiority of the microsurgical technique lies in the 10–25× optical magnification, which allows precise identification of the testicular artery, small collateral veins, and lymphatic vessels, thereby minimizing inadvertent ligation and preventing persistent or recurrent varicocele.

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