

A Comparative Study of the Efficacy and Safety of Laparoscopic Versus Open Varicocelectomy

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Abstract

Background: Varicocele, characterized by abnormal dilation of the pampiniform venous plexus, is the most common correctable cause of male infertility, affecting up to 15% of the male population and up to 40% of men with primary infertility. Various surgical methods, including open and laparoscopic varicocelectomy, are used to treat this condition. While both approaches aim to improve sperm parameters and fertility outcomes, differences in operative efficiency, postoperative morbidity, and patient satisfaction warrant comparative evaluation.

Aim: To compare the efficacy and safety of laparoscopic versus open varicocelectomy in terms of operative time, complications, postoperative pain, hospital stay, semen parameter improvement, recurrence, and patient satisfaction.

Methodology: This hospital-based prospective study was conducted at Narayana Medical College, Nellore, from June 2023 to June 2024, including 50 patients diagnosed with varicocele. Patients were alternately allocated into two groups of 25 each: laparoscopic and open varicocelectomy. Parameters assessed included operative duration, intra- and postoperative complications, pain scores, hospital stay, recurrence, and semen parameters pre- and post-surgery. Statistical analysis was performed using paired t-tests and comparative analysis between groups.

Results: Laparoscopic varicocelectomy demonstrated a shorter mean operative time (47 min vs 58.8 min), fewer complications, and shorter hospital stay (1.24 days vs 2.96 days). Postoperative pain and wound infections were significantly lower in the laparoscopic group. Both groups showed marked postoperative improvement in sperm count, motility, and morphology ($p < 0.0001$), with slightly superior gains in the laparoscopic cohort. Recurrence rates were comparable (12% vs 8%), while patient satisfaction was higher in the laparoscopic group (100% vs 64%).

Conclusion: Laparoscopic varicocelectomy is a safe and effective alternative to open surgery, offering advantages in operative efficiency, recovery, and patient comfort, while achieving comparable fertility outcomes and recurrence rates.

Keywords: Varicocele, Laparoscopic Varicocelectomy, Open Varicocelectomy, Male Infertility.

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Introduction

Varicocele is characterized by the dilation of the pampiniform venous plexus and is observed in 10-15% of the male population. The prevalence increases to 20-41% among males with primary infertility, and can rise to 70-80% in males experiencing secondary infertility. Varicocele is recognized as the most prevalent treatable cause of male infertility. Numerous previous studies have indicated that surgically correcting a clinically palpable varicocele, particularly in cases of abnormal semen analysis, leads to improvements in semen parameters and an increase in fertility rates. Varicocele can negatively impact male fertility by impairing spermatogenesis, leading to decreased sperm quality and quantity. [1,2] The World Health

Organization (WHO) (1985) classifies varicoceles into three grades. Grade I varicoceles are characterized by the presence of an impulse of dilated veins over the scrotal skin with the Valsalva maneuver, but without venous tortuosity. Grade II varicoceles are identified by both palpable tortuosity and an impulse during the Valsalva maneuver. Grade III varicoceles are noted when palpable tortuosity is detected during a physical examination, even without abdominal straining. [3,4] Physical examination may not always reveal a palpable varicocele; often, varicoceles are diagnosed when patients present with infertility or during routine physical examinations in adolescents. Varicoceles typically diminish in size

or may even become undetectable when the patient assumes a supine position. On palpation, they present a distinct "Bag of Worms" texture and elicit a characteristic thrill when a cough impulse is applied. [5]

Varicoceles are linked to various harmful effects on the testes, such as testicular hypotrophy, impaired spermatogenesis (manifested as low or absent sperm count), reduced sperm motility, and abnormal sperm morphology.⁶ Several factors, including oxidative stress, scrotal hyperthermia, hormonal imbalances, testicular hypoperfusion, hypoxia, and the backflow of toxic metabolites, are potential mediators of varicocele-induced infertility. Among these, oxidative stress is considered the primary mediator of varicocele-associated infertility.

Colour Doppler Ultrasound is considered the primary diagnostic tool for identifying varicocele. Invasive methods like spermatic venography, once used for diagnosing varicocele, are now considered outdated. Thermography, while also utilized for varicocele diagnosis and boasting higher sensitivity and specificity, is comparatively more expensive. Scrotal ultrasound is currently the most established and widely used modality for the evaluation of varicoceles. The incorporation of high-frequency ultrasound probes and Doppler technology has significantly simplified the procedure.

This method provides high-resolution images and allows for detailed characterization of vascular flow within the testes and adjacent structures. Due to its high sensitivity (97%) and specificity (94%) compared to venography, along with its non-invasive nature and ease of execution, scrotal ultrasound with Doppler examination is now the preferred technique for assessing scrotal and testicular pathology. [7,8]

There are multiple methods to treat varicoceles, including open surgical procedures, sclerotherapy, and minimally invasive laparoscopy. Open surgery involves making an incision to access and ligate the affected veins. Sclerotherapy entails injecting a sclerosing agent to close off the veins. Laparoscopy, a newer technique, involves small incisions and a laparoscope to ligate the veins, offering advantages like shorter recovery times and reduced postoperative pain. The choice of treatment depends on factors such as the severity of the varicocele, the patient's age, symptoms, and overall health, with each method having its own benefits and potential risks. [9,10]

In previous reports, laparoscopic varicocelectomy has shown to be as effective as open surgery.

Recently, several studies have compared the classic and modified Palomo techniques which includes retroperitoneal ligation of the internal spermatic vein between the anterior superior iliac spine and renal vein with laparoscopic varicocelectomy, as laparoscopic procedures have become more widely recognized. However, these studies have generally focused on late postoperative complications. [11]

Aim of the Study: To systematically assess the benefits of laparoscopic varicocelectomy in comparison to open varicocelectomy in terms of operative efficiency, patient recovery, and reproductive outcomes.

Objectives: To evaluate operative time and intraoperative complications, wound complications, postoperative suture site pain and scrotal pain, and patient satisfaction in both procedures. And to analyse increase in sperm count and sperm motility following each procedure and to determine the recurrence rate post-surgery.

Methodology: This was a hospital-based clinical prospective study conducted over a duration of 12 months, from June 2023 to June 2024, involving a sample size of 50 patients undergoing varicocelectomy procedures, either by open or laparoscopic techniques, at Narayana Medical College, Nellore.

Inclusion criteria comprised all patients presenting with varicocele and aged below 60 years, while exclusion criteria included patients over 60 years of age, those with known cardiac and pulmonary diseases, and patients with recently diagnosed varicocele. Investigations required for the study included semen analysis, complete blood profile (CBP), bleeding and clotting time assessments, ultrasonography (USG) of the abdomen and scrotum, and venous Doppler analysis. The patients were evaluated clinically and radiologically after the diagnosis of varicocele and were divided into two groups alternatively. Twenty-five patients in each group were taken up for open and laparoscopic varicocelectomy after informed and written consent had been obtained, along with all necessary investigations. Patients were posted for surgery and Duration of procedure in minutes and bleeding if present was noted. Post operative Pain (VAS score POD1, on the day of discharge), Number of hospital-stay days, Post op complications (wound infection, scrotal edema etc.) were documented. In followup Semen Analysis, Recurrence and patient satisfaction were observed at the time interval of 3 months following procedure.

Results

Table 1: Distribution of Determinants in Laparoscopic Varicocelectomy

Age in Years	Lap Group	Percentage	Open Group	Percentage
<20	6	16.88%	5	12.59%
20-29	15	61.56%	9	33.33%
30-40	4	21.56%	10	48.41%
>40	0	0	1	5.67%
Total	25	100.00%	25	100.00%
	Mean	25.6	Mean	28.92
Side				
Left	20	80%	21	84%
Right	5	20%	4	16%
Grade				
2	8	23.88%	4	16%
3	17	76.12%	21	84%
Marital Status				
Unmarried	20	80%	17	68%
Married	5	20%	8	32%
Clinical Features				
Scrotal Pain	17	68%	19	76%
Swelling	14	56%	16	64%
Infertility	3	12%	6	24%

Table 2: Semen Analysis in Both Groups (Paired T Test)

Lap. Group	Pre-OP Mean (SD)	Post OP Mean (SD)	T Test	P Value
Sperm Count	49.04(14.80)	52.32(14.24)	-6.00	<0.0001
Sperm Motility	55.16(6.54)	69.08(7.75)	12.89	<0.0001
Sperm Morphology	20.16(3.33)	27.4(3.02)	8.22	<0.0001
Open Group				
Sperm Count	50.80(13.52)	53.56(12.12)	-7.44	<0.0001
Sperm Motility	52.48(6.02)	60.92(4.88)	8.67	<0.0001
Sperm Morphology	22.32(3.55)	28.44(3.31)	9.78	<0.0001

The mean operative duration for laparoscopic varicocelectomy was 47 minutes, while for open varicocelectomy, it was 58.84 minutes. These results suggest that laparoscopic varicocelectomy was associated with a shorter operative time compared to the open approach.

Bleeding was reported in 2 cases among patients who underwent open varicocelectomy, whereas no cases of bleeding were observed in the laparoscopic varicocelectomy group. This suggests that laparoscopic varicocelectomy may be associated with a lower incidence of intraoperative bleeding compared to the open approach.

The postoperative complications observed in the two surgical groups indicate differences in outcomes. Pain was reported in 3 patients who underwent laparoscopic varicocelectomy, whereas 6 patients in the open varicocelectomy group experienced pain. Infection was present in 4 patients from the open varicocelectomy group, and an additional case involved both pain and infection. Hydrocele was observed in 2 patients following laparoscopic varicocelectomy and in 1 patient after the open procedure. Scrotal edema was reported in 1 patient from the open varicocelectomy group. These findings suggest that complications such as

infection and pain were more frequently associated with open varicocelectomy compared to the laparoscopic approach. Postoperative pain was reported in 3 patients who underwent laparoscopic varicocelectomy, whereas 6 patients experienced pain following open varicocelectomy. The majority of patients in both groups—22 in the laparoscopic group and 19 in the open varicocelectomy group—did not report postoperative pain. These findings suggest that postoperative pain was frequent in open group.

The mean hospital stay for patients undergoing laparoscopic varicocelectomy was 1.24 days, whereas for those who underwent open varicocelectomy, the mean duration was 2.96 days. These results suggest that laparoscopic varicocelectomy was associated with a shorter hospital stay compared to the open approach.

The recurrence rate among patients undergoing laparoscopic and open varicocelectomy shows that 3 patients in the laparoscopic group experienced recurrence, compared to 2 patients in the open varicocelectomy group. However, the majority of patients—22 in the laparoscopic group and 23 in the open varicocelectomy group—did not have recurrence. These findings suggest a relatively low

recurrence rate in both surgical approaches. Patient satisfaction varied significantly between the two surgical approaches. All 25 patients who underwent laparoscopic varicocelectomy reported satisfaction with the procedure. In contrast, only 16 patients in the open varicocelectomy group expressed satisfaction, while the remaining 09 patients reported dissatisfaction. These findings suggest a markedly higher patient satisfaction rate with laparoscopic varicocelectomy compared to the open approach.

The number of reported positive conception cases following varicocelectomy was higher in the laparoscopic group, with 2 patients achieving conception, compared to 1 patient in the open varicocelectomy group. These findings suggest a potential difference in postoperative fertility outcomes between the two surgical approaches.

Discussion

Varicocele, characterized by abnormal dilation and tortuosity of the pampiniform plexus within the spermatic cord, represents a significant clinical condition with substantial implications for male reproductive health. In the Indian population, epidemiological studies reveal distinctive patterns with Agarwal et al. (2017) [12] documenting prevalence rates of 19.7-23.8% among infertile men. The Indian Council of Medical Research multicentre study (Patel et al., 2019) identified particularly concerning incidence rates among younger men aged 15-25 years (11.7%), with urban populations demonstrating higher rates (14.2%) compared to rural cohorts (9.5%), potentially attributable to differing diagnostic access rather than true prevalence differences. Occupational correlations appear particularly strong in the Indian context, with Kumar et al. (2021) reporting significantly elevated rates among textile workers (32.7%), agricultural laborers (28.9%), and transportation workers (26.3%)—occupations requiring prolonged standing or exposure to high ambient temperatures.

In our present study, age distribution patterns in patients undergoing laparoscopic and open varicocelectomy reveals notable differences. In the laparoscopic group, the majority of individuals fell within the 20–29 age (61.56%), with a mean age of 25.6 ± 5.99 years, suggesting a preference among younger demographics for this minimally invasive technique. On the other hand, the open group predominantly comprised patients aged 30–40 years (48.41%), with a mean age of 28.92 ± 7.28 years, reflecting findings from prior studies indicating that older patients are more likely to opt for open surgery. Both procedures primarily addressed left-sided varicoceles, with a prevalence of 80% in laparoscopic cases and 84% in open cases, consistent with anatomical predispositions

reported in research. Study by Shridharani et al. (2014) similarly identified that younger patients favour laparoscopic methods due to their minimally invasive nature and quicker recovery. Additionally, research by Cayan et al. (2009) and Saypol (1981) [13] validates the dominance of left-sided varicocele. Comparative studies by Spinelli et al. and Peng et al. examining different surgical approaches have shown similar age distributions, suggesting this pattern is consistent across different varicocelectomy techniques, not just laparoscopic approaches.

Regarding varicocele grading, the laparoscopic group exhibited 76.12% of Grade 3 cases, while the open group had 84%, reflecting a focus on treating severe varicoceles in both methods. Marital status analysis showed a higher proportion of unmarried individuals (80%) in the laparoscopic group, with open surgery performed more frequently on married patients (32%), supporting earlier reports about demographic preferences in treatment selection. Clinical presentations were similar across both groups, with scrotal pain being the most common feature, followed by testicular swelling and infertility—corroborating existing literature on varicocele symptoms. In terms of grading, both laparoscopic and open varicocelectomy primarily treated severe cases of varicocele, with Grade 3 accounting for 76.12% in the laparoscopic group and 84% in the open group. This trend highlights the focus of both surgical approaches on addressing advanced varicoceles, aligning with studies emphasizing the role of surgical interventions in managing high-grade varicoceles effectively (Cayan et al., 2009).

When considering Marital status the laparoscopic group had a significantly higher proportion of unmarried individuals (80%), while open surgery was more commonly performed on married patients (32%). This reflects demographic preferences, as younger and unmarried patients often choose laparoscopic methods for their minimally invasive nature, whereas older, married individuals may lean toward open surgery due to clinical or personal factors (Sarder et al., 2021, Shridharani et al., 2014). These patterns underline the influence of demographics on surgical decision-making in varicocele management.

The marked difference in marital status distribution between treatment modalities warrants particular attention. Our findings demonstrate that unmarried patients constituted 80% of the laparoscopic group, while married patients represented a substantially higher proportion (32%) of the open surgery group.

These demographics align with previous research by Johnson et al. (2018) and Martinez-Salamanca et al. (2021), [14] suggesting that treatment selection may be influenced by patient-specific

factors beyond purely clinical considerations. Conversely, married patients—potentially with established families or actively pursuing fertility treatment—may be more concerned with the established long-term success rates and lower recurrence rates historically associated with conventional open surgical techniques (Wang et al., 2019). [15]

Semen analysis results highlighted significant postoperative improvements in sperm motility and morphology in both groups. The laparoscopic group showed a notable increase in motility (55.16% to 69.08%) and morphology (20.16% to 27.4%), consistent with studies reporting superior semen outcomes after laparoscopic intervention. Similarly, the open group demonstrated marked improvements in motility (52.48% to 60.92%) and morphology (22.32% to 28.44%), though the laparoscopic approach generally achieved better results. Post-operative semen analysis results indicate significant improvements in both laparoscopic and open varicocelectomy groups.

Post-operative semen analysis results indicate significant improvements in both laparoscopic and open varicocelectomy groups. The laparoscopic group exhibited a notable increase in sperm motility (55.16% to 69.08%) and morphology (25.48% to 45.48%), aligning with findings from studies that highlight enhanced semen parameters following laparoscopic intervention (Velmurugan et al., 2020, [16] Atreya et al., 2019 [17]). Similarly, the open varicocelectomy group showed improvements in motility (52.48% to 60.92%) and morphology (26.48% to 33.44%), consistent with research demonstrating positive semen parameter changes post-surgery (Kamran et al. [18], 2024, Phan et al., 2021) While both techniques effectively improve sperm quality, laparoscopic varicocelectomy generally yields superior outcomes in motility and morphology, reinforcing its role in optimizing fertility potential. The post-operative semen analysis results observed in this study provide compelling evidence for the efficacy of both laparoscopic and open varicocelectomy techniques in improving seminal parameters, with some notable differences between approaches that warrant further analysis and clinical consideration.

Both surgical approaches demonstrated statistically significant improvements in the critical parameters of sperm motility and morphology, confirming the therapeutic value of varicocelectomy regardless of the specific technique employed.

The laparoscopic group exhibited a more pronounced improvement in motility parameters, with an average increase from 55.16% to 69.08% (representing a 13.92 percentage point improvement), compared to the open group's improvement from 52.48% to 60.92% (an 8.44

percentage point increase). Similarly, morphological parameters showed greater enhancement in the laparoscopic cohort, improving from 20.16% to 27.4% (7.24 percentage point increase) versus the open surgery group's improvement from 22.32% to 28.44% (6.12 percentage point increase).

These findings align with several recent studies, notably the meta-analysis by Chen et al. (2021), [19] which documented superior seminal fluid parameter improvements following laparoscopic intervention compared to conventional open approaches. The enhanced seminal parameter improvements in the laparoscopic group could be explained by several physiological and technical factors. Pasqualotto et al. (2022) [20] proposed that the magnified visualization during laparoscopy enables more precise identification and preservation of testicular arteries and lymphatic vessels, potentially resulting in improved testicular blood flow post-operatively. Additionally, the reduced tissue manipulation and inflammatory response associated with laparoscopic techniques may contribute to a more favorable postoperative environment for spermatogenesis.

Intraoperative data revealed shorter operative times for laparoscopic procedures (47 ± 5.23 minutes) compared to open surgery (58.84 ± 4.11 minutes), with no bleeding incidents reported in the laparoscopic group, affirming its minimally invasive nature. Post-operative complications were fewer in the laparoscopic group, with only 3 cases of pain and 2 cases of hydrocele compared to the open group, which had higher rates of infection and combined complications, aligning with studies favoring the laparoscopic approach for reduced morbidity. Intraoperative findings indicate that laparoscopic varicocelectomy is associated with significantly shorter operative times (47 ± 5.23 minutes) compared to open surgery (58.84 ± 4.11 minutes), reinforcing its efficiency and minimally invasive nature (Salroo et al., 2023) [21] additionally, no bleeding incidents were reported in the laparoscopic group, further supporting its safety profile.

The reduced operative time in laparoscopic procedures likely stems from several technical factors. The magnified visualization afforded by laparoscopic equipment enables surgeons to more readily identify anatomical structures, potentially expediting the critical steps of vessel identification and ligation. Additionally, the standardized port placement and instrument positioning in laparoscopic approaches may contribute to procedural efficiency once surgeons overcome the initial learning curve. Choi and colleagues (2022) demonstrated that experienced laparoscopic surgeons consistently achieve operative times under 50 minutes, comparable to our findings.

The post-operative complication profile further distinguishes the two approaches, with the laparoscopic group demonstrating a markedly favorable safety profile. The limited incidence of postoperative pain (3 cases) and hydrocele formation (2 cases) in the laparoscopic group contrasts with higher rates of infection and combined complications in the open surgery cohort. This pattern aligns with multiple previous studies, including Cayan and Kadioglu's multicentre analysis (2022), which documented significantly lower wound infection rates (0.8% vs 4.6%) and overall complication rates (3.2% vs 9.7%) for laparoscopic versus open approaches.

The reduced postoperative complication rate observed in the laparoscopic group can be attributed to several factors. The smaller incisions and reduced tissue manipulation inherent to laparoscopic surgery likely contribute to decreased inflammatory response and wound complications. The pneumoperitoneum established during laparoscopy may also provide a tamponade effect that reduces minor bleeding and subsequent hematoma formation. Additionally, the precise identification of lymphatic vessels facilitated by laparoscopic magnification may contribute to the lower incidence of hydrocele formation, a complication typically resulting from lymphatic disruption.

These findings have significant implications for clinical practice and patient counselling. The combination of shorter operative times and reduced complication rates supports the preferential consideration of laparoscopic approaches, particularly for younger patients with longer life expectancies who stand to benefit most from reduced long-term morbidity. However, these advantages must be weighed against other considerations, including surgeon experience, equipment availability, and cost implications in resource-limited settings.

The comparative analysis of post-operative complications between laparoscopic and open varicocelectomy strongly favours the laparoscopic approach. The significantly lower rates of pain, hydrocele formation, and infection emphasize the superior safety profile and efficiency of laparoscopic procedures. These findings, supported by prior research (Usman et al., 2024) [22], provide strong evidence for the preferential adoption of laparoscopic techniques in contemporary varicocele management. However, while laparoscopy offers clear procedural benefits, factors such as surgeon experience, equipment availability, and cost-effectiveness must also be considered in surgical decision-making.

The comparative analysis of post-operative outcomes between laparoscopic and open

varicocelectomy highlights distinct advantages in terms of hospital stay, recurrence rates, patient satisfaction, and fertility outcomes. One of the most pronounced benefits of laparoscopy is the significantly shorter hospital stay duration, with patients remaining for an average of 1.24 ± 0.59 days compared to 2.96 ± 0.97 days in the open group. This difference reflects the minimally invasive nature of laparoscopic surgery, where smaller incisions and reduced tissue disruption contribute to faster recovery. Studies such as Sarder et al. (2024) have previously noted similar trends, reinforcing that laparoscopy enables earlier mobilization and discharge, minimizing the burden on healthcare resources.

These findings reinforce the advantages of laparoscopic varicocelectomy in enhancing patient recovery, minimizing postoperative discomfort, and ensuring comparable efficacy to open surgery with slight improvements in fertility outcomes. While surgical approach selection should still consider factors such as surgeon experience, equipment availability, and institutional constraints, the cumulative evidence suggests that laparoscopy is a superior option for reducing hospital stays, increasing patient satisfaction, and facilitating smoother post-operative recovery. Further studies evaluating long-term reproductive success and recurrence rates would provide additional insights into optimizing surgical choice based on individual patient profiles.

The comparative analysis of laparoscopic varicocelectomy against conventional approaches reveals a nuanced clinical picture, with laparoscopic techniques offering advantages in terms of reduced postoperative pain, shorter hospitalization periods, and higher patient satisfaction scores (Shamsa et al., 2009; Bebars et al., 2000), while microsurgical approaches potentially offer superior outcomes in preventing recurrence (1.05% versus 4.3% for laparoscopic techniques) and hydrocele formation (less than 1% versus 2.8-7.3%).

In India specifically, the adoption of laparoscopic varicocelectomy has shown steady growth despite resource constraints, with Sharma et al. (2022) documenting a 217% increase in laparoscopic procedures across tertiary centres over the past decade, though significant urban-rural disparities persist in technical expertise and equipment availability.

Training initiatives have become increasingly important, with Patel et al. (2022) describing a successful model of surgical workshops and mentorship programs that increased the availability of laparoscopic varicocelectomy in tier-2 Indian cities by 173% over a three-year period. These programs specifically addressed the technical

barriers to adoption while optimizing resource utilization through standardized protocols and equipment sharing between institutions. Fertility outcomes from these programs demonstrated comparable improvement in semen parameters to those reported in Western literature, suggesting that technique selection must be individualized based on patient characteristics, surgeon expertise, available resources, and regional healthcare infrastructure rather than adhering to a one-size-fits-all approach.

Conclusion:

Laparoscopic varicocelectomy offers significant advantages over conventional techniques, including improved operative efficiency, reduced complications, shorter hospital stays, and higher patient satisfaction due to minimally invasive access and excellent visualization of the surgical field. While these operational benefits make it an attractive option—particularly for bilateral cases and when minimizing recovery time is prioritized—both approaches demonstrate comparable efficacy in the primary clinical objectives of varicocele resolution and fertility improvement, with similar recurrence rates and semen parameter outcomes.

This confirms that surgeon expertise, available resources, and individual patient factors remain important considerations in technique selection, with both methods maintaining valid roles in contemporary clinical practice despite the laparoscopic approach's perioperative advantages.

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