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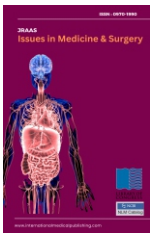

Research Article

Section: Radiodiagnosis

Hospital-Based Study to Assess One-Year Follow-Up of Efficacy in Patients of Varicose Vein Treated with 1470 Endovenous Diode Laser Ablation

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HIGHLIGHTS

- Excellent vein occlusion
- Significant symptom improvement
- Minimal postoperative complications
- Reduced recurrence rates
- Safe minimally invasive treatment

Key Words:
Varicose veins
Endovenous laser ablation
1470 nm diode laser
Recurrence
VCSS

ABSTRACT

Introduction: Varicose veins are a common manifestation of chronic venous disease and result from valvular incompetence and venous reflux, leading to pain, heaviness, edema, skin changes, and reduced quality of life. Endovenous laser ablation has emerged as a minimally invasive alternative to conventional surgery because it offers less postoperative morbidity, shorter recovery, and better patient acceptance. The 1470 nm diode laser, with greater absorption by water in the vein wall, is expected to produce more effective and uniform ablation with fewer complications. **Aim & Objective:** To assess the one-year efficacy of 1470 nm endovenous diode laser ablation in patients with varicose veins using duplex ultrasound, and to evaluate symptom improvement, recurrence, procedural parameters, post-treatment complications, and patient-reported outcomes. **Materials & Methods:** This prospective observational study was conducted at G.R. Medical College and J.A. Group of Hospitals, Gwalior, from April 2024 to September 2025 in 94 adults with primary symptomatic varicose veins (CEAP C2 to C6). All underwent 1470 nm endovenous diode laser ablation and completed a one-year follow-up for assessment of clinical profile, duplex findings, procedural details, complications, recurrence, and Venous Clinical Severity Score. **Results:** Complete occlusion at 12 months was achieved in 94.68% cases, while recurrence occurred in 5.3%. Radial fiber showed significantly lower recurrence than bare fiber ($p = 0.012$). Mean VCSS improved from 8.11 ± 3.02 before treatment to 2.55 ± 3.17 in 12 months ($p < 0.001$). Complications were minor and included ecchymosis, transient paresthesia, and thrombophlebitis. **Conclusion:** 1470 nm endovenous diode laser ablation is a safe, effective, and minimally invasive treatment for varicose veins with excellent one-year outcomes.

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INTRODUCTION

Varicose veins represent a highly prevalent manifestation of chronic venous disease, characterized by dilated, elongated, and tortuous superficial veins resulting from venous valve incompetence and reflux. This condition commonly affects the lower limbs and is associated with a wide clinical spectrum ranging from asymptomatic cosmetic concerns to significant morbidity such as limb heaviness, pain, edema, skin pigmentation, lipodermatosclerosis, and venous ulceration [1]. Pathophysiology primarily involves sustained venous hypertension due to valvular dysfunction, leading to progressive venous dilatation and structural changes in the venous wall. Over time, these alterations contribute to worsening symptoms & complications, significantly impairing quality of life & functional capacity in affected individuals [2].

The burden of varicose veins is considerable across both developed and developing countries, with a higher prevalence observed among individuals with prolonged standing occupations, sedentary lifestyles, obesity, and genetic predisposition [3]. In hospital-based settings, a large proportion of patients present at relatively advanced stages of disease, often with chronic symptoms or complications. This delayed presentation underscores the importance of effective and durable treatment strategies that not only alleviate symptoms but also prevent disease progression and recurrence [4]. Historically, conventional surgical procedures such as high ligation and stripping of the great saphenous vein were widely practiced and considered standard treatment. However, these techniques are associated with increased postoperative pain, longer recovery periods, higher risk of complications, and delayed return to normal activities [5]. Pathology, treatment, and one-year outcomes of 1470 nm endovenous diode laser ablation for varicose veins are shown in **Figure 1**.

With advancements in vascular surgery and interventional techniques, there has been a paradigm shift toward minimally invasive modalities for the management of varicose veins. Endovenous thermal ablation techniques, including laser and radiofrequency ablation, have largely replaced traditional surgery due to their superior safety profile, reduced morbidity, and improved patient satisfaction [6].

Endovenous laser ablation (EVLA) is a widely accepted technique that utilizes laser energy delivered through an intraluminal fiber to induce thermal damage to the vein wall. This leads to endothelial destruction, collagen contraction, and eventual fibrosis, resulting in permanent occlusion of the incompetent vein and elimination of reflux [7].

Technological evolution in EVLA has led to the introduction of higher wavelength systems, particularly the 1470 nm diode laser, which represents a significant advancement over earlier low-wavelength lasers. Unlike earlier systems that primarily targeted hemoglobin, the 1470 nm wavelength is preferentially absorbed by water in the vein wall, allowing more homogeneous energy distribution & controlled thermal injury [8]. This targeted mechanism minimizes damage to surrounding tissues thereby reducing reducing postoperative pain, bruising, and complications. The use of radial fiber technology further enhances this effect by providing circumferential energy emission, ensuring uniform vein wall ablation, and reducing the risk of perforation [9]. Mechanism and steps of endovenous laser ablation (EVLA) causing vein fibrosis and permanent occlusion **(Figure 2)**.

Clinical studies evaluating the efficacy of 1470 nm EVLA have demonstrated excellent outcomes in terms of both anatomical and clinical success. One-year follow-up data from prospective studies have shown venous occlusion rates as high as 98.6%, with significant improvement in clinical severity scores and ulcer healing rates [10]. These findings indicate that EVLA is not only effective in achieving vein closure but also in improving functional outcomes and symptom relief. Additionally, the procedure is associated with a favorable safety profile, with most complications being minor and transient, such as mild pain, ecchymosis, or temporary paresthesia, while serious complications like deep vein thrombosis are rare [11].

Another important advantage of EVLA is its minimally invasive nature, which allows it to be performed as an outpatient procedure under local anesthesia. Patients typically experience rapid recovery, early ambulation, and quick return to daily activities. Compared to conventional surgery, EVLA has been shown to result in fewer postoperative complications and improved short-term outcomes, making it a preferred treatment modality in modern vascular practice. These benefits are particularly relevant in hospital-based settings, where reducing hospital stay and optimizing resource utilization are important considerations [12].

Despite the well-documented short-term efficacy of EVLA, long-term outcomes and durability of treatment remain critical factors in evaluating its overall effectiveness. Recurrence of varicose veins remains a concern, and understanding the factor's influencing recurrence is essential for improving treatment strategies. One-year follow-up plays a crucial role in assessing sustained vein closure, recurrence rates, and long-term symptom relief. It also provides insight into the real-world performance of the procedure outside controlled trial settings, especially in diverse patient populations encountered in hospital-based studies [13].

Furthermore, the evaluation of one-year outcomes helps in identifying procedural variables that may influence success, such as vein diameter, energy delivered, fiber type, and adherence to postoperative care protocols. It also allows assessment of patient-centered outcomes, including quality of life, cosmetic satisfaction, and functional improvement. In the context of developing healthcare systems, such as in India, hospital-based studies are particularly valuable in generating region-specific data that reflect local disease patterns, patient characteristics, and healthcare delivery challenges [14].

In addition, the increasing adoption of EVLA necessitates continuous evaluation to ensure optimal utilization and standardi-

zation of the technique. Evidence from mid-term and long-term studies suggests that 1470 nm EVLA provides stable and durable results with sustained vein closure and low complication rates, reinforcing its role as an effective treatment modality for chronic venous insufficiency [15]. However, variations in clinical practice and patient factors highlight the need for further observational studies to validate these outcomes across different settings. The assessment of one-year follow-up outcomes in patients undergoing 1470 nm endovenous diode laser ablation is essential for establishing its long-term efficacy, safety, and clinical applicability. Such hospital based evaluations contribute significantly to the existing body of evidence, and help refine treatment protocols, improve patient selection, and enhance overall clinical outcomes in the management of varicose veins.

This study aims to evaluate the one-year outcomes of varicose veins treated with 1470 nm endovenous diode laser ablation using duplex ultrasound. It assesses symptom improvement, recurrence rates, procedural parameters, post treatment complications, & patient reported outcomes, while also analyzing data to generate evidence that can be disseminated through scientific publications to support effective management of varicose veins.

MATERIALS & METHODS

This prospective observational study evaluated patients with primary symptomatic varicose veins treated using a 1470-nm diode laser, documenting demographic characteristics, clinical presentation, procedural details, and one-year outcomes, including recurrence, recanalization, neovascularization, and complications. Conducted at G.R. Medical College and J.A. Group of Hospitals, Gwalior, from April 2024 to September 2025, it ensured standardized protocols and follow-up. Adults above 18 years with CEAP C2-C6 disease were included, while patients with deep vein thrombosis, pregnancy, age above 65 years, thrombophlebitis, and related exclusions were omitted. Ethical approval and informed consent were obtained, maintaining confidentiality and procedural safety.

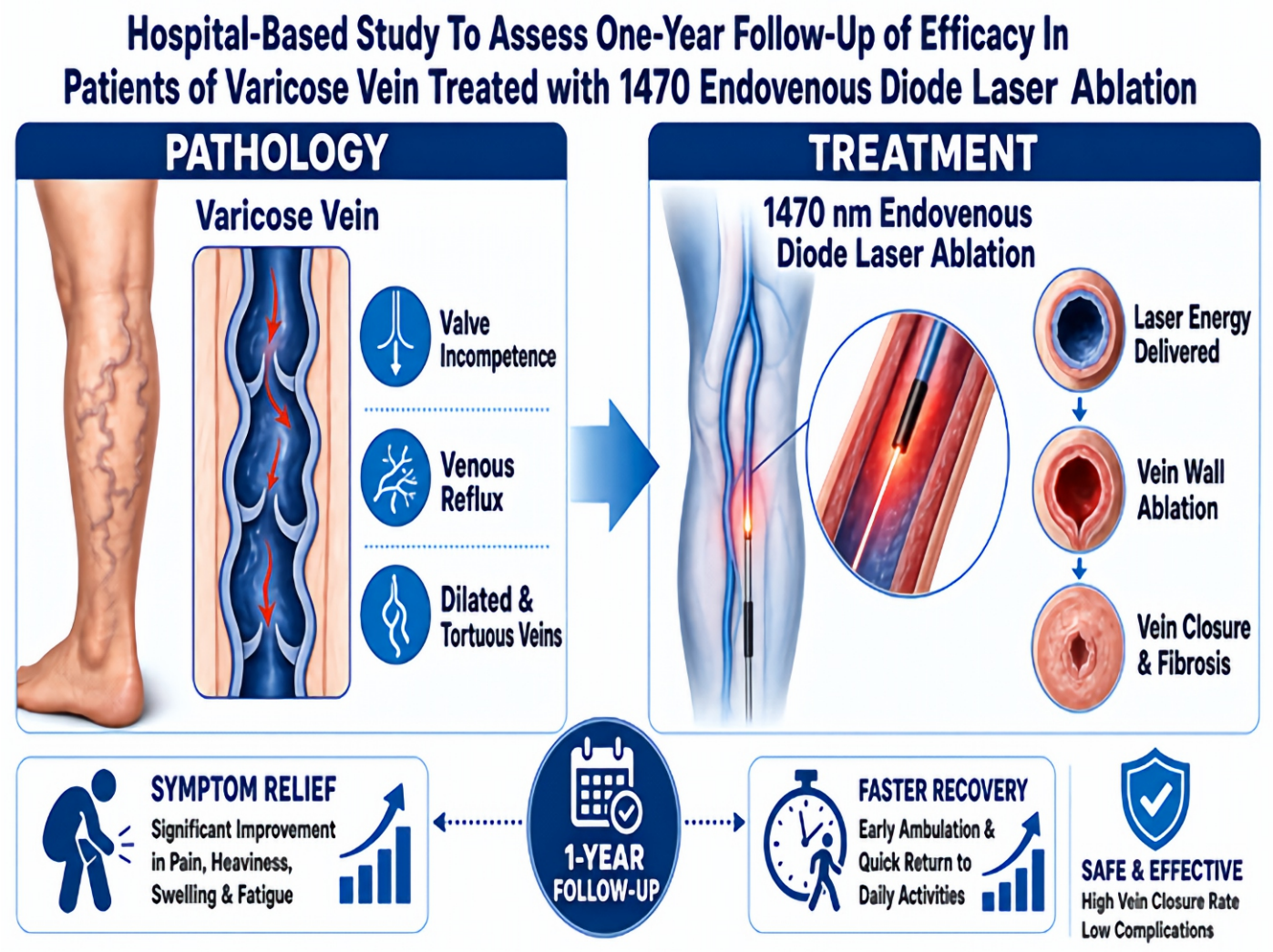

Figure 1. Pathology, treatment procedure, and one-year follow-up outcomes of 1470 nm endovenous diode laser ablation in patients with varicose veins.

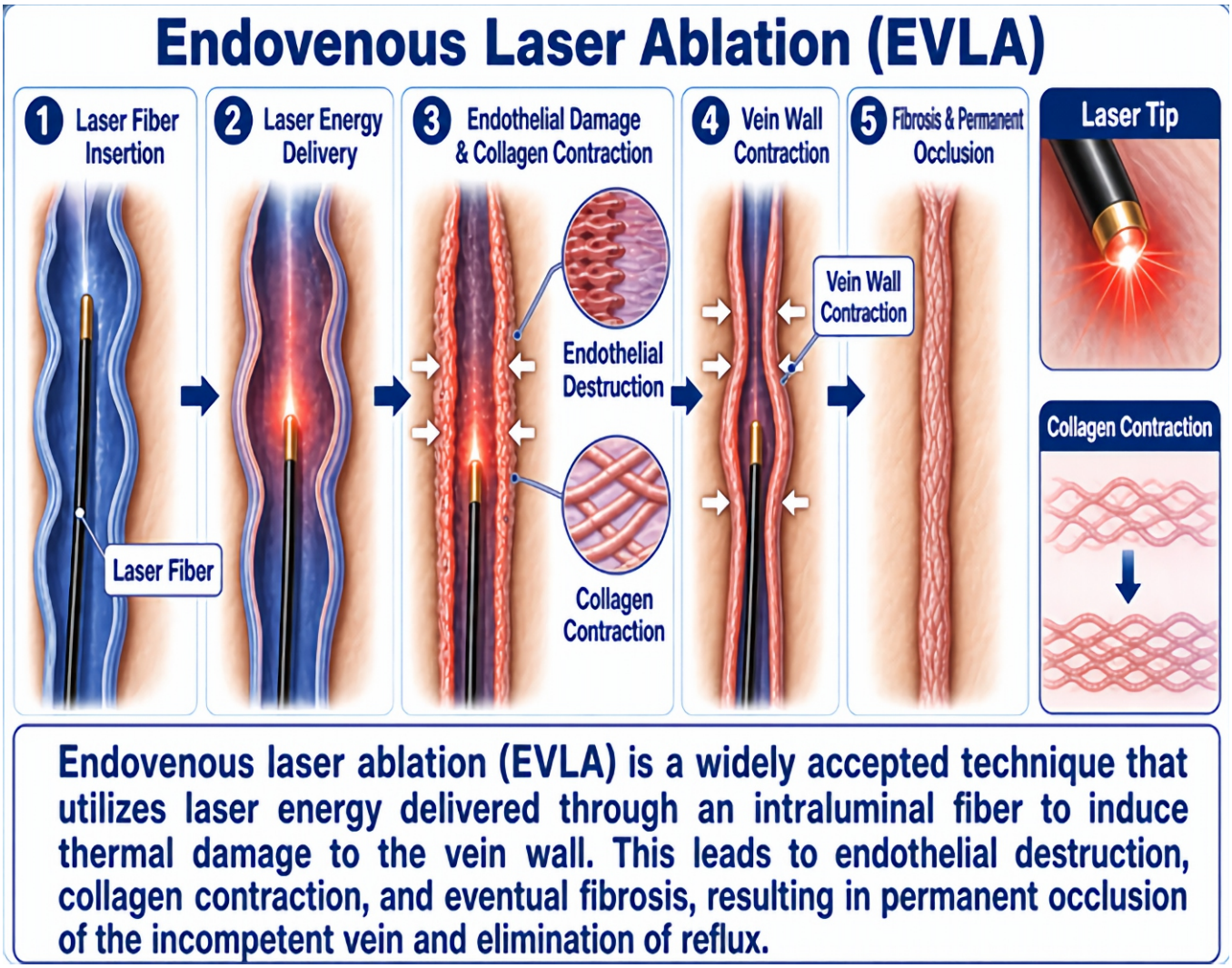

Figure 2. Mechanism and procedural steps of endovenous laser ablation (EVLA) leading to vein wall fibrosis and permanent occlusion.

RESULTS

The study population demonstrates a predominant concentration in the 31–50 years age group (62.8%), indicating that varicose vein disease requiring intervention is most prevalent in the economically active middle-aged population, while younger (17%) and older (>50 years, 20.2%) groups contribute comparatively less. A marked male predominance (74.5% vs 25.5%) suggests either higher disease burden or greater healthcare-seeking behavior among males in this setting. These demographic trends imply that occupational factors, prolonged standing, and lifestyle exposures in middle age may significantly influence disease occurrence. Overall, the baseline distribution highlights a demographic skew that is important for interpreting treatment outcomes and generalizability of one-year efficacy results. The 12-month duplex outcome demonstrates a high success rate, with complete ablation achieved in 94.68% of cases, indicating excellent efficacy of 1470 nm endovenous laser ablation. Only a small proportion showed partial recanalization (3.2%), while neova scularization and failure were minimal (1.06 % each).

This reflects durable vein closure with low recurrence related complications. Overall, the findings confirm strong long-term procedural effectiveness with minimal adverse outcomes **(Table 1)**. The one-year follow-up shows a high proportion of patients without recurrence (94.7%), with only 5.3% experiencing recurrence. This indicates sustained clinical effectiveness of the 1470 nm endovenous laser ablation over time. The low recurrence rate reflects durable vein closure and minimal disease progression. Overall, the findings confirm excellent long-term efficacy with low risk of relapse **(Table 2)**. The analysis shows a statistically significant association between fiber type and recurrence ($\chi^2 = 6.36$, $p = 0.012$), indicating that treatment outcome is influenced by the type of laser fiber used. Recurrence was higher with bare fiber (3/16) compared to radial fiber (2/78), suggesting better efficacy of radial fibers. The markedly lower recurrence in the radial group reflects improved energy distribution and vein wall contact. Overall, radial fiber demonstrates superior outcomes with significantly reduced recurrence rates **(Table 3)**.

The VCSS score shows a significant reduction from 8.11 ± 3.02 pre-treatment to 2.55 ± 3.17 at 12 months, with a mean difference of 5.55. This improvement is statistically highly significant ($t = 27.548$, $p < 0.001$), indicating marked clinical recovery following intervention. The substantial decline reflects effective symptom relief and disease regression. Overall, the findings confirm strong therapeutic efficacy of the procedure in improving clinical severity **(Table 4)**. The complication profile shows ecchymosis as the most common (8.5%), followed by transient paresthesia (5.3%) and thrombophlebitis (4.3%). All complications are relatively low in frequency and predominantly minor in nature. The presence of transient paresthesia suggests temporary nerve irritation without long-term deficit. Overall, the procedure demonstrates a favorable safety profile with minimal and manageable complications **(Figure 3)**. The procedural profile shows predominant use of radial fiber (83%) compared to bare fiber (17%), indicating a preference for advanced fiber technology. Adjunct phlebectomy was performed in 22% of cases, while the majority (78%) did not require additional intervention. This suggests that endovenous laser ablation alone was sufficient in most patients. Overall, the findings reflect an effective standalone procedural application with selective use of adjunct therapy **(Table 5)**. The CEAP class distribution shows a predominance of C2 (38) and C3 (28), indicating that most patients presented in early to moderate stages. Fewer cases were seen in advanced stages, with C4 (18), C5 (6), and C6 (4), reflecting limited progression to severe disease. This pattern suggests earlier diagnosis and intervention in our cohort. Overall, disease burden is mainly concentrated in less advanced CEAP classes **(Figure 4)**. The symptom profile shows pain (84%) and heaviness (81.9%) as the most common presentations, indicating predominant early venous insufficiency. Edema was present in 68.1%, reflecting moderate disease progression in a significant proportion. Skin pigmentation was less frequent (29.8%), suggesting fewer advanced chronic changes. Overall, symptoms are mainly early and functional rather than late-stage complications **(Table 6)**. The parameter distribution shows below-knee reflux in 31.9% of cases and incompetent perforators in 20.2%, indicating that segmental venous insufficiency is relatively common. The higher proportion of below-knee reflux suggests distal venous involvement as a significant contributor to disease pathology. Incompetent perforators also represent an important source of reflux, though less frequently. Overall, multiple anatomical factors contribute to venous insufficiency in this cohort **(Figure 5)**. The ulcer status shows that most patients had no ulcer (84 cases), with only a small proportion having healed (6) or active ulcers (4). This indicates that the majority presented before progression to advanced ulcerative stages. The low frequency of active ulcers reflects a limited severe disease burden. Overall, findings suggest early-stage presentation with minimal chronic complications (**Figure 6)**.

Table 1: 12-month duplex outcome

Outcome	Frequency	Percentage (%)
Ablated/occluded	89	94.68
Partial recanalization	3	3.20
Neovascularization	1	1.06
Failure	1	1.06
Total	94	100

Table 2: Recurrence at One-Year Follow-Up

Outcome	Frequency	Percentage (%)
No recurrence	89	94.7
Recurrence	5	5.3
Total	94	100

Table 3: Association between fiber type and recurrence at one-year follow-up

Fiber Type	Recurrence	No Recurrence	Total	χ^2 value	p-value
Bare	3	13	16	6.36	**0.012**
Radial	2	76	78		
Total	5	89	94		

Table 4: Comparison of VCSS before and after treatment

Variable	Mean ± SD	Mean Difference	t-value	p-value
VCSS (pre-treatment)	8.11 ± 3.02	**5.55**	**27.548**	**<0.001**
VCSS (12 months)	2.55 ± 3.17			

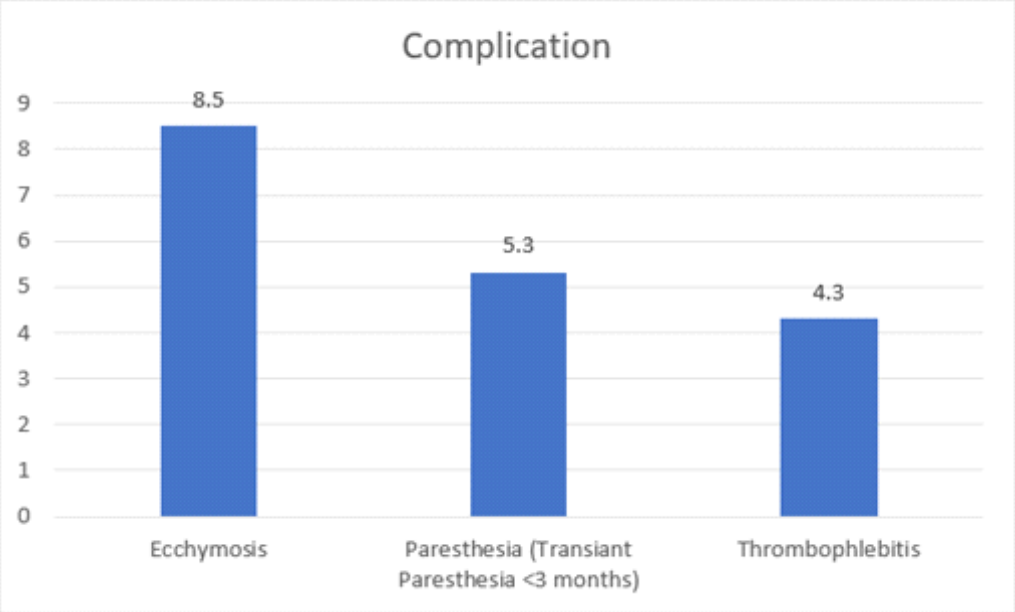

Figure 3. Graphical representation of Complication

Table 5: Procedural characteristics

Parameter	Frequency	Percentage (%)
Radial fiber	78	83
Bare fiber	16	17
Adjunct phlebectomy (Yes)	21	22
Adjunct phlebectomy (No)	73	78

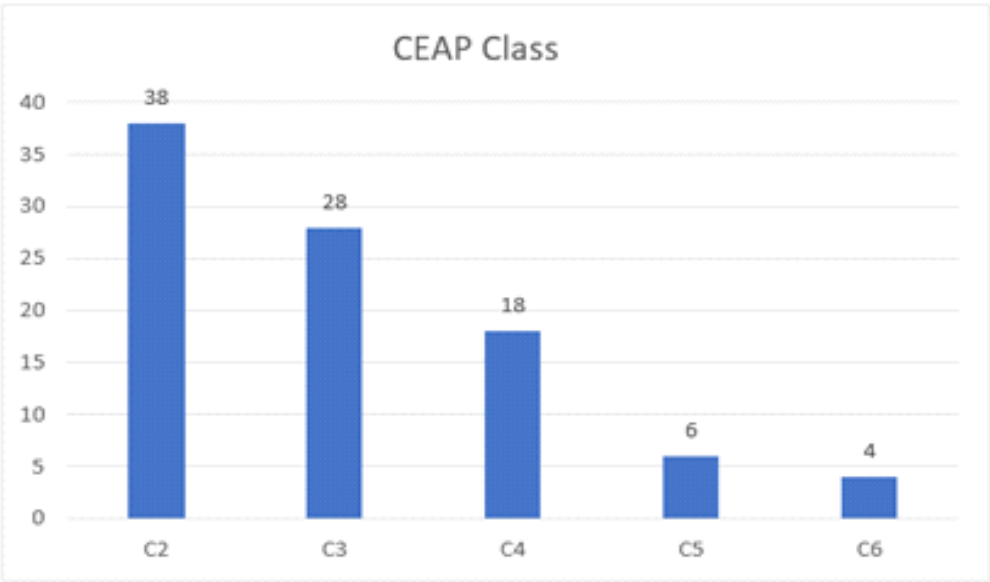

Figure 4. Graphical representation of CEAP Class

Table 6: Distribution of clinical symptoms

Symptom	Yes (%)	No (%)
Pain	84	16
Heaviness	81.9	18.1
Edema	68.1	31.9
Skin pigmentation	29.8	70.2

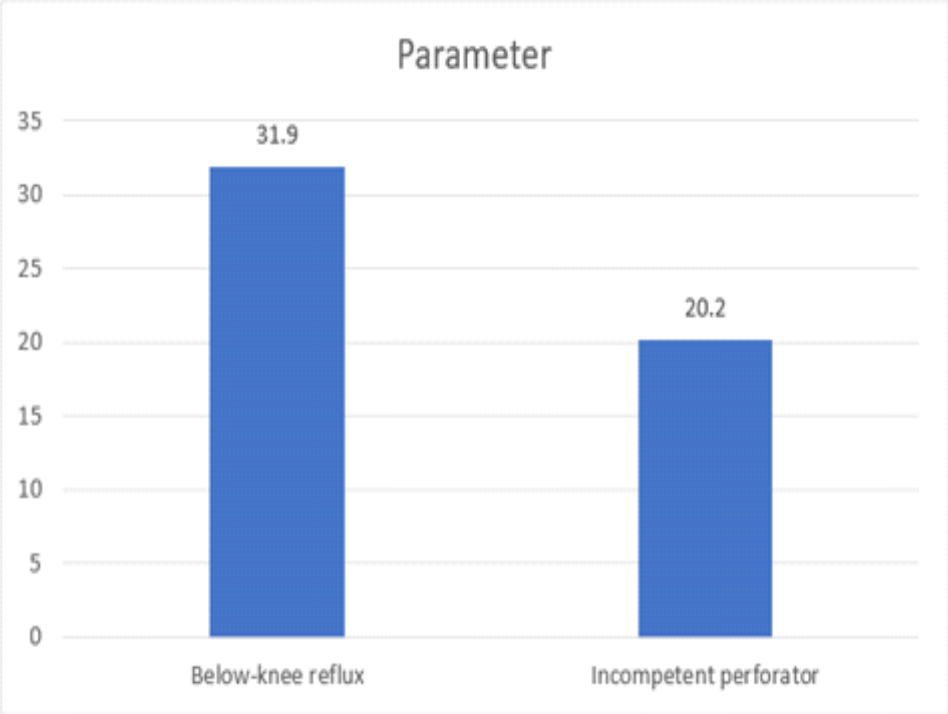

Figure 5. Graphical representation of Parameter

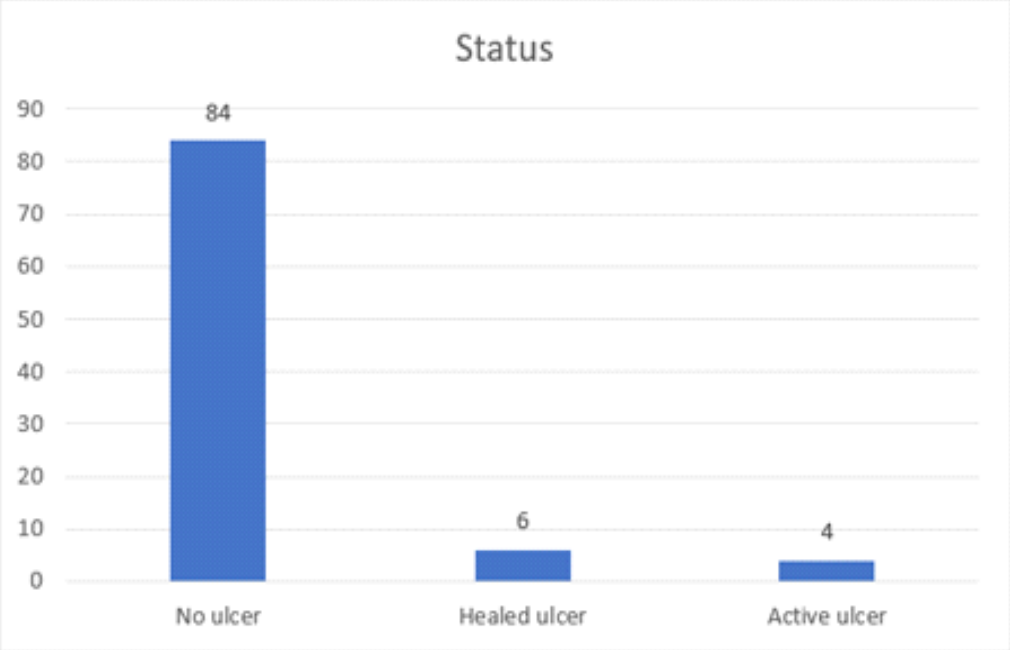

Figure 6. Graphical representation of Status

DISCUSSION

The present study evaluated the efficacy and safety of 1470-nm endogenous laser ablation (EVLA) in 94 patients with primary varicose veins and demonstrated a high technical success rate, with 94.68% of treated veins achieving complete occlusion at 12 months and a low recurrence rate of 5.3%. These findings are comparable with Pannier et al. (2009) and Rathod et al. (2010), who reported occlusion rates of 100% and 98.61%, respectively, and von Hodenberg et al. (2015), who observed 99.6% occlusion with minimal recurrence [10,17,18]. Slight variation in occlusion rates may be attributed to differences in patient characteristics, vein diameter, and procedural parameters. While short-term outcomes were excellent, studies such as Lawaetz et al. (2017) have shown higher recurrence rates over longer follow-up, indicating that durability may vary over time [19].

A key finding of the study was the significant association between fiber type and recurrence, with higher recurrence observed in the bare fiber group compared to radial fiber ($p = 0.012$). This aligns with Hirokawa et al. (2015), who demonstrated improved outcomes and reduced complications with radial fiber systems, as well as Pannier et al. (2011) and Zerweck et al. (2014), who reported high occlusion rates with minimal complications using radial fiber [20-22]. In contrast, demographic and clinical variables such as age, CEAP classification, GSV diameter, reflux time, and BMI were not significantly associated with recurrence, consistent with Leopardi et al. (2019), although Spreafico et al. (2014) suggested that advanced disease and larger vein diameter may influence failure rates [23, 24]. Procedurally, the predominant use of radial fiber (83%) and optimized energy delivery (mean LEED 71.37 J/cm) reflect adherence to contemporary EVLA practices. These findings are comparable with Park et al. (2014) and Pannier et al. (2009), who emphasized that lower LEED values maintain efficacy while reducing complications [18,25]. The selective use of adjunct phlebectomy also suggests a tailored minimally invasive approach without compromising outcomes.

The safety profile observed in the study was excellent, with only minor complications such as ecchymosis (8.5%), transient paresthesia (5.3%), and thrombophlebitis (4.3%), and no major complications such as deep vein thrombosis or skin burns. These findings are comparable to those of Rathod et al. (2010) and Park et al. (2014), who also reported low complication rates with EVLA [10,26]. The lower incidence of complications in the present study may be attributed to optimized energy delivery and predominant use of radial fiber, which ensures uniform energy distribution and minimizes tissue injury.

Significant clinical improvement was demonstrated by a marked reduction in Venous Clinical Severity Score (VCSS) from 8.11 ± 3.02 to 2.55 ± 3.17 at 12 months ($p < 0.001$), indicating substantial reduction in disease severity and symptom burden. These findings are consistent with Dumantepe et al. (2012) and Caliskan et al. (2013), who reported significant improvement in clinical scores and pain reduction following EVLA [27,28]. Symptomatically, reduction in pain, heaviness, and edema reflects effective elimination of venous reflux and improved hemodynamics.

Patient satisfaction in the study exceeded 94%, with the majority reporting being very satisfied or satisfied. This is in agreement with Pannier et al. (2009) and Spreafico et al. (2014), who also reported high satisfaction rates following EVLA [18,24]. A highly significant association between satisfaction and recurrence ($p < 0.001$) further highlights that successful vein occlusion directly influences patient-perceived outcomes.

Overall, the study findings strongly support that 1470-nm EVLA is an effective, safe, and minimally invasive treatment for varicose veins, offering high occlusion rates, low recurrence, minimal complications, and excellent patient satisfaction. Procedural factors, particularly fiber type and optimized energy delivery, play a crucial role in determining outcomes, while baseline demographic and clinical variables have a limited impact when adequate ablation is achieved.

CONCLUSION

The present study demonstrates that 1470-nm endovenous laser ablation (EVLA) is a highly effective, safe, and minimally invasive treatment for primary varicose veins, achieving 94.68% occlusion and 5.3% recurrence at one year, comparable to Pannier et al. and Rathod et al. [21,10]. Radial fiber showed significantly lower recurrence than bare fiber, while demographic and clinical variables had no significant influence. Significant VCSS reduction (8.11 to 2.55; $p < 0.001$) and >94% patient satisfaction confirms clinical benefit. Complications were minor with no major adverse events. Overall, EVLA offers excellent outcomes, though long-term multicentric studies are needed for durability assessment.

LIMITATIONS & FUTURE PERSPECTIVES

The study's limitations include a single-centre setting, a relatively small sample size, and a short study duration, which may limit the broader applicability of the results. Future studies should incorporate multicentre designs with larger populations to enhance validity, assess long-term outcomes, and investigate advanced diagnostic and management approaches. Such efforts will improve overall patient care and help minimize complications.

CLINICAL SIGNIFICANCE

The clinical significance of this study lies in its potential to bridge the gap between research findings and practical healthcare applications. It emphasizes the importance of translating scientific observations into meaningful improvements in patient care, diagnosis, and treatment outcomes. By highlighting real-world relevance, the study contributes to evidence-based medical practice and supports informed clinical

decision making. Ultimately, the findings aim to enhance patient quality of life, optimize therapeutic strategies, and promote better disease management in clinical settings.

ABBREVIATIONS

EVLA: Endovenous Laser Ablation
GSV: Great Saphenous Vein
BMI: Body Mass Index
LEED: Linear Endovenous Energy Density
VCSS: Venous Clinical Severity Score
DVT: Deep Vein Thrombosis

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AUTHOR CONTRIBUTIONS

All authors significantly contributed to the study conception and design, data acquisition, or data analysis and interpretation. They participated in drafting the manuscript or critically revising it for important intellectual content, consented to its submission to the current journal, provided final approval for the version to be published, and accepted responsibility for all aspects of the work. Additionally, all authors meet the authorship criteria outlined by the International Committee of Medical Journal Editors (ICMJE) guidelines.

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CONFLICT OF INTEREST

Authors declared that there is no conflict of interest.

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None

ETHICAL APPROVAL & CONSENT TO PARTICIPATE

All necessary consent & approval was obtained by authors.

CONSENT FOR PUBLICATION

All necessary consent for publication was obtained by authors.

DATA AVAILABILITY

All data generated and analyzed are included within this research article. The datasets utilized and/or analyzed in this study can be obtained from the corresponding author upon a re-asonable request.

USE OF ARTIFICIAL INTELLIGENCE (AI) & LARGE LANGUAGE MODEL (LLM)

The authors confirm that no AI & LLM tools were used in thewriting or editing of the manuscript, and no images were altered or manipulated using AI & LLM.

AUTHOR'S NOTE

This article serves as an important educational tool for the scientific community, offering insights that may inspire future research diretions. However, they should not be relied upon independently when making treatment decisions or developing public health policies.

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