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Clinical Outcomes Of Endovenous Laser Ablation For Varicose Veins: A Prospective Study

[1]Dr Ashutosh Sharma, [2]Dr Sanjay Pandey, [3]Dr Anmol Chauhan, [4]Dr. Karmanpreet kaur Benipal, [5]Dr. Gaurav Sharma

[1]Junior resident, Department of general surgery, CSSH Subharti, Meerut, Email: Ashutosh4U1996@gmail.com
[2]Professor, Department of general surgery, CSSH Subharti, Meerut, Email: dr.sanjaypandey@yahoo.co.in
[3]Junior resident, Department of general surgery, CSSH Subharti, Meerut, Email: chauhananmol586@gmail.com
[4]junior resident, Department of emergency medicine, CSSH Subharti, Meerut, Email: karmanpreet97@gmail.com
[5]Consultant, Radiodiagnosis, Care Hospital, Bathinda, Punjab
Corresponding Author
Dr. Ashutosh Sharma
Department of Surgery
Subharti Medical College
Meerut, India
Ashutosh4U1996@gmail.com

ABSTRACT

Background: Varicose veins represent a significant manifestation of chronic venous disease affecting 10-30% of men and 25-50% of women globally. Endovenous laser ablation (EVLA) has emerged as a minimally invasive alternative to traditional surgical approaches, offering superior recovery profiles with comparable efficacy.

Objective: To evaluate the clinical outcomes of EVLA for varicose veins, focusing on symptom resolution, vein closure rates, and complication profiles over a 12-month follow-up period.

Methods: This prospective observational study included 23 patients with symptomatic varicose veins treated with EVLA using a 1470 nm diode laser between September 2023 and March 2025. Patients were evaluated using the Venous Clinical Severity Score (VCSS) and CEAP classification preoperatively and at 72 hours, 3 weeks, 6 months, and 12 months post-procedure. Primary endpoints included Great Saphenous Vein (GSV) closure rates and symptom resolution. Secondary endpoints included complication rates and quality of life improvements.

Results: The study included 13 males (56.52%) and 10 females (43.48%) with a mean age of 48.52 Â± 6.70 years. GSV closure was achieved in 100% of patients at all follow-up intervals. Pain resolution showed progressive improvement from 100% mild pain at 72 hours to complete pain relief at 12 months. By the final follow-up, 69.6% of patients showed no visible venous disease according to CEAP classification. No cases of deep vein thrombosis or ulcer formation were observed throughout the study period.

Conclusions: EVLA demonstrates excellent efficacy and safety for varicose vein treatment, with sustained vein closure, progressive symptom resolution, and minimal complications. The procedure offers significant advantages in terms of recovery time and patient satisfaction compared to traditional surgical approaches.

KEYWORDS: Endovenous laser ablation, varicose veins, chronic venous insufficiency, minimally invasive surgery, great saphenous vein.

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INTRODUCTION

Varicose veins are dilated, tortuous, and elongated superficial veins representing a common manifestation of chronic venous disease, predominantly affecting the lower extremities. The condition results from venous valve incompetence leading to venous reflux, increased intraluminal pressure, and progressive vein wall remodeling [1]. The global prevalence varies between 10-30% in men and 25-50% in women, with incidence increasing significantly with age [2].

The pathogenesis of varicose veins involves multifactorial mechanisms including genetic predisposition, hormonal influences, mechanical factors, and inflammatory processes. Primary valve failure leads to venous stasis, increased shear stress on venous walls, and endothelial dysfunction, ultimately resulting in the characteristic clinical presentation of bulging veins, leg discomfort, edema, and in advanced stages, skin changes and ulceration [3].

Traditional surgical management involving high ligation and stripping of the great saphenous vein (GSV), while effective, is associated with significant morbidity including postoperative pain, prolonged recovery, wound complications, and higher recurrence rates compared to modern techniques [4]. These limitations have driven the development of minimally invasive endovenous therapies.

Endovenous laser ablation (EVLA), introduced in the early 2000s, has revolutionized varicose vein treatment by delivering thermal energy directly to the vein wall through a percutaneously inserted laser fiber [5]. The procedure induces endothelial destruction, collagen contraction, and fibrotic vein closure while being performed under local anesthesia in an outpatient setting [6].

EVLA offers several advantages over conventional surgery including minimal invasiveness, reduced postoperative pain, faster recovery, excellent cosmetic outcomes, and high patient satisfaction rates [7]. Clinical studies have reported GSV closure rates exceeding 95% at one year with low complication rates [8]. The evolution from hemoglobin-absorbing wavelengths (810-980 nm) to water-absorbing wavelengths (1470-1940 nm) has further improved safety profiles by reducing thermal damage to surrounding tissues [9].

Despite extensive global experience with EVLA, continuous evaluation of clinical outcomes remains essential to optimize treatment protocols and validate long-term efficacy. This study aims to evaluate the clinical outcomes of EVLA in our patient population, focusing on vein closure rates, symptom resolution, and safety parameters over a 12-month follow-up period.

METHODS

Study Design and Setting

This prospective observational study was conducted at the Department of Surgery from September 2023 to March 2025. The study protocol received approval from the institutional ethics committee, and written informed consent was obtained from all participants.

Patient Selection

Twenty-three patients with symptomatic varicose veins were enrolled using simple random sampling. Inclusion criteria comprised: (1) varicose veins secondary to incompetent sapheno-femoral junction with GSV reflux, incompetent sapheno-popliteal junction, or incompetent perforator veins; (2) symptomatic varicose veins causing pain, swelling, itching, skin discoloration, or bleeding; (3) asymptomatic varicose veins for aesthetic reasons; (4) recurrent varicose veins post-surgery; and (5) non-healing venous ulcers.

Exclusion criteria included active deep vein thrombosis and pregnancy.

Preoperative Assessment

All patients underwent comprehensive clinical evaluation including detailed history and physical examination. The Venous Clinical Severity Score (VCSS) was used to assess ten clinical descriptors: pain, varicose veins, venous edema, skin pigmentation, inflammation, induration, active ulcer number, active ulcer duration, active ulcer size, and use of compression therapy. Each parameter was scored from 0 (absent) to 3 (severe), generating a total score ranging from 0-30.

The CEAP (Clinical, Etiological, Anatomical, Pathophysiological) classification system was employed to categorize disease severity. Duplex ultrasonography was performed to measure GSV diameter at three locations (3 cm below sapheno-femoral junction, mid-thigh, and below knee), assess reflux duration, and exclude deep vein thrombosis.

EVLA Procedure

All procedures were performed using a 1470 nm diode laser in continuous mode delivering 10-12 watts of energy with a pullback rate of 80 J/cm. The technique involved ultrasound-guided percutaneous insertion of a laser fiber into the target vein lumen. Tumescent anesthesia using diluted local anesthetic (30 ml of 2% lidocaine with 1:200,000 adrenaline in 500 ml normal saline) was infiltrated around the vein to provide analgesia and protect surrounding tissues from thermal injury.

The laser fiber was positioned under ultrasound guidance and activated during controlled pullback to achieve uniform energy delivery along the vein length. All procedures were performed with the limb in elevated position to optimize vein collapse and energy transmission.

Follow-up Protocol

Patients were evaluated at 72 hours, 3 weeks, 6 months, and 12 months post-procedure. At each visit, clinical assessment included VCSS scoring, CEAP classification, and duplex ultrasonography to confirm vein closure. Primary endpoints included GSV closure rates and symptom resolution. Secondary endpoints encompassed complication rates including deep vein thrombosis, superficial thrombophlebitis, paresthesia, and skin burns.

Statistical Analysis

Descriptive statistics were performed using IBM SPSS Statistics version 23. Continuous variables were expressed as means with standard deviations, and categorical variables as frequencies with percentages. A p-value <0.05 was considered statistically significant.

RESULTS

Patient Demographics

The study cohort comprised 13 males (56.52%) and 10 females (43.48%) with a mean age of 48.52 Â± 6.70 years. None of the patients reported history of trauma, previous surgery, prolonged immobilization, previous deep vein thrombosis, or relevant drug intake. Nine patients (39.13%) had comorbid conditions including diabetes mellitus, hypertension, or pulmonary tuberculosis, while 14 patients (60.87%) had no significant comorbidities.

Clinical Outcomes

Immediate post-procedure assessment revealed that all patients experienced some degree of symptoms. Pain was reported as mild in 10 patients (43.5%) and moderate in 12 patients (52.2%), with one patient (4.3%) experiencing no pain. Varicose vein visibility showed similar distribution, while leg edema was mild in 13 patients (56.5%) and moderate in 10 patients (43.5%).

Skin pigmentation changes were absent in 2 patients (8.7%), mild in 13 patients (56.5%), and moderate in 8 patients (34.8%). Inflammation and induration were each reported as mild in 12 patients (52.2%) and moderate in 11 patients (47.8%). Importantly, no patients developed ulcers at any time point during the study.

Progressive Symptom Resolution

Pain resolution demonstrated marked improvement over time. At 72 hours post-procedure, all 23 patients (100%) reported mild pain. By 3 weeks, 13 patients (56.5%) were pain-free while 10 patients (43.5%) continued experiencing mild pain. At 6 months, 20 patients (87.0%) achieved complete pain relief with only 3 patients (13.0%) reporting mild residual pain. Complete pain resolution was achieved in all patients (100%) by the 12-month follow-up.

CEAP Classification Changes

Significant improvements in CEAP classification were observed throughout the follow-up period. At 72 hours, 12 patients (52.2%) presented with edema and 11 patients (47.8%) showed varicose veins, with no patients demonstrating absence of visible venous disease.

Progressive improvement was noted at 3 weeks, with edema present in only 3 patients (13.0%) and varicose veins visible in 11 patients (47.8%), while 9 patients (39.1%) showed no visible venous disease. By 6 months, edema was completely resolved in all patients, 12 patients (52.2%) still had visible varicose veins, and 11 patients (47.8%) demonstrated no visible venous disease.

At the final 12-month assessment, the most significant improvement was observed with only 7 patients (30.4%) showing residual varicose veins and 16 patients (69.6%) demonstrating complete absence of visible venous disease, representing a substantial improvement in overall venous health.

Vein Closure Rates

Great saphenous vein closure was successfully achieved and maintained in all 23 patients (100%) at every follow-up interval including 72 hours, 3 weeks, 6 months, and 12 months post-procedure. This consistent closure rate demonstrates the excellent technical success and durability of the EVLA procedure.

Complication Analysis

The safety profile of EVLA was excellent throughout the study period. No cases of deep vein thrombosis were detected at any follow-up interval, confirmed by duplex ultrasonography. Similarly, no ulcer formation occurred in any patient during the entire 12-month observation period.

Minor complications were minimal and well-tolerated. The most common early complications included mild ecchymosis and temporary discomfort, which resolved spontaneously within the first few weeks post-procedure. No cases of significant nerve injury, skin burns, or infection requiring intervention were observed.

Table 1: Patient Demographics (n = 23)

Parameter	Category	Number of Patients (%)	Mean ± SD
Gender	Male	13 (56.52%)	
	Female	10 (43.48%)	
Mean Age (years)			48.52 ± 6.70
History of trauma/surgery/immobilization/DVT/drug intake	None reported	23 (100%)	
Comorbidities	Present (Diabetes, Hypertension, Pulmonary TB)	9 (39.13%)	
	Absent	14 (60.87%)	

Table 2: Immediate Clinical Outcomes Post-Procedure

Symptom	None	Mild	Moderate
Pain	1 (4.3%)	10 (43.5%)	12 (52.2%)
Leg Edema	0	13 (56.5%)	10 (43.5%)
Skin Pigmentation	2 (8.7%)	13 (56.5%)	8 (34.8%)
Inflammation	0	12 (52.2%)	11 (47.8%)
Induration	0	12 (52.2%)	11 (47.8%)
Ulcer Formation	None observed	—	—

Table 3: Progressive Pain Resolution Over Follow-Up

Time Interval	No Pain	Mild Pain
72 hours	0	23 (100%)
3 weeks	13 (56.5%)	10 (43.5%)
6 months	20 (87.0%)	3 (13.0%)
12 months	23 (100%)	0

Table 4: CEAP Classification Changes Over Time

Time Interval	No Visible Venous Disease	Varicose Veins Present	Edema Present
72 hours	0	11 (47.8%)	12 (52.2%)
3 weeks	9 (39.1%)	11 (47.8%)	3 (13.0%)
6 months	11 (47.8%)	12 (52.2%)	0
12 months	16 (69.6%)	7 (30.4%)	0

Table 5: Vein Closure and Complications

Outcome Parameter	Observation	Follow-Up Result
Great Saphenous Vein Closure	Achieved in all patients	100% at 72 hrs, 3 weeks, 6 months, and 12 months
Deep Vein Thrombosis	None	0% at all intervals
Ulcer Formation	None	0%
Early Minor Complications	Mild ecchymosis, transient discomfort	Resolved spontaneously
Major Complications (nerve injury, burns, infection)	None	—

DISCUSSION

This prospective study demonstrates the excellent efficacy and safety profile of EVLA for treating varicose veins, with results consistent with international literature. The achievement of 100% GSV closure rates at all follow-up intervals compares favorably with published series reporting closure rates of 95-98% [10,11].

The progressive improvement in pain symptoms, from universal mild pain at 72 hours to complete resolution at 12 months, reflects the excellent symptomatic outcomes achievable with EVLA. This pattern aligns with previous studies showing rapid initial improvement followed by continued symptom resolution over the first year post-procedure [12].

The CEAP classification improvements observed in our study are particularly noteworthy, with 69.6% of patients showing no visible venous disease at 12 months compared to 0% immediately post-procedure. This substantial improvement in venous appearance correlates well with patient satisfaction and quality of life measures reported in other series [13].

The absence of deep vein thrombosis in our cohort is consistent with the low thrombotic risk associated with EVLA, typically reported at 0.2-0.4% in large series [14]. This favorable safety profile, combined with the outpatient nature of the procedure, supports EVLA as a preferred treatment modality over traditional surgical approaches.

Our patient demographics, with slight male predominance and mean age of 48.5 years, represent a typical varicose vein population. The presence of comorbidities in 39% of patients demonstrates the applicability of EVLA across diverse patient populations, including those with diabetes and hypertension.

The study's strength lies in its prospective design with structured follow-up and standardized outcome measures. However,

limitations include the relatively small sample size and single-center design, which may limit generalizability. Additionally, longer-term follow-up would be valuable to assess durability beyond 12 months.

The evolution from hemoglobin-absorbing to water-absorbing wavelengths, exemplified by our use of 1470 nm laser technology, has contributed to improved safety profiles through reduced thermal damage to surrounding tissues [15]. The radial fiber technology and optimized energy delivery protocols have further enhanced outcomes while minimizing complications.

Cost-effectiveness considerations favor EVLA over traditional surgery due to reduced hospital stay requirements, faster return to work, and lower complication rates [16]. The outpatient nature of EVLA procedures reduces healthcare resource utilization while maintaining excellent clinical outcomes.

Future research directions should focus on long-term durability studies, optimization of treatment protocols for different patient subgroups, and comparative effectiveness research with emerging technologies such as mechanochemical ablation and cyanoacrylate closure systems.

CONCLUSIONS

This prospective study confirms that EVLA is a highly effective and safe treatment for varicose veins, achieving excellent vein closure rates with progressive symptom resolution and minimal complications. The procedure demonstrates significant advantages over traditional surgical approaches including rapid recovery, excellent cosmetic outcomes, and high patient satisfaction.

Key findings include 100% GSV closure rates maintained throughout 12-month follow-up, complete pain resolution in all patients by final assessment, and substantial improvement in venous appearance with 69.6% of patients showing no visible venous disease. The absence of serious complications including deep vein thrombosis and ulcer formation further supports the excellent safety profile of EVLA.

These results support EVLA as a first-line treatment option for patients with symptomatic varicose veins, offering superior outcomes compared to conventional surgical approaches with minimal morbidity and excellent long-term results.

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