

Correlation Between Saphenous Vein Diameter and Outcomes of Endovenous Laser Ablation in Patients with Varicose Veins: A Systematic Review

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ABSTRACT

Aim: This systematic review aims to determine whether preoperative saphenous vein diameter influences the success rate outcomes of endovenous laser ablation (EVLA) in patients with varicose veins. **Methods:** A systematic review with a comprehensive search for articles published in the last decade was performed on ScienceDirect and PubMed. After the screening process, three high-quality studies about the correlation between preoperative saphenous vein diameter and outcomes of EVLA procedure success were identified on inclusion criteria. The Newcastle-Ottawa Scale (NOS) was employed to assess the quality. **Results:** The larger diameter of the saphenous vein is an independent risk factor predictor of technical failure, as consistently demonstrated by the synthesis of the included studies (n=3). Veins measuring greater than 12 mm in diameter were associated with a higher incidence of partial recanalization compared with smaller diameter veins. According to the research's review, EVLA is effective, but the effectiveness depends largely on the energy-to-diameter ratio. To achieve sustained fibrotic occlusion, larger veins need a higher Linear Endovenous Energy Density (LEED). **Conclusion:** The diameter of the saphenous vein is a key predictor of EVLA performance. While larger diameters are linked to an increased risk of recanalization, tailored procedural strategies such as a higher energy delivery, optimized tumescent compression, and the use of advanced laser technologies may improve outcomes. Accurate preoperative measurement of vein diameter is essential for patient selection and personalized treatment planning.

Keywords: varicose veins, saphenous vein diameter, endovenous laser ablation (EVLA), outcomes

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INTRODUCTION

Venous insufficiency is a common disease affecting approximately 30% of the population. The long-term effects of venous insufficiency is venous stasis ulcers, which affect less than 1% of the population¹. Chronic venous insufficiency (CVI) impacts approximately 20% to 30% of people globally, posing a significant public health issue. Chronic venous insufficiency (CVI) is more prevalent among older individuals and females².

The CEAP classification (Clinical, Etiological, Anatomical, and

Pathophysiological) is employed worldwide to evaluate the severity of chronic venous insufficiency (CVI) and to standardize its treatment². Clinical stages (C) range from C0, signifying the absence of external symptoms of venous disease, to C6, indicating the presence of active venous ulcers. Examples of intermediate stages include C1 (reticular veins or telangiectasia), C2 (varicose veins, the most common clinical manifestation), C3 (venous edema), C4 (secondary skin changes such as dermatitis or hyperpigmentation), and C5 (healed venous ulcers)^{2,3}. Patients typically pursue surgical intervention upon reaching

stages C2 to C6, especially when conservative measures such as compression stockings do not mitigate symptoms including heaviness, pain, and nocturnal cramps³.

In the last two decades, a significant paradigm shift has occurred in the management of Great Saphenous Vein (GSV) incompetence⁴. Although effective, traditional surgical techniques such as high ligation and stripping (HLS) are associated with significant postoperative pain, extended recovery periods, and a heightened risk of wound infections^{3,7}. Endovenous Laser Ablation (EVLA) has thus become the most efficacious minimally invasive treatment^{4,8}. In numerous clinical studies, EVLA has demonstrated primary occlusion rates over 90% and is advised for patients exhibiting confirmed axial reflux (often >0.5 seconds on Duplex Ultrasound)^{3,7}. Benefits include less surgical trauma, enhanced aesthetic results, and a rapid resumption of normal activities^{4,8}.

The effectiveness of EVLA's technique fluctuates based on the anatomical profile, although its elevated success rates^{6,9}. The procedure induces immediate collagen contraction and permanent fibrotic degeneration of the vein by delivering thermal energy, quantified as Linear Endovenous Energy Density (LEED), to the vessel wall⁵. Patients exhibiting a substantial preoperative saphenous vein diameter provide a considerable challenge⁶. The augmented blood volume within the lumen of significantly dilated veins (often exceeding 10–12 mm) serves as a "heat sink"^{5,6}. The blood absorbs and dissipates the thermal energy intended for the vein wall to prevent the vessel from reaching the critical temperature needed for irreversible transmural damage⁵.

Although numerous vascular surgeons recommend modifying laser power or pullback speed for larger veins, there is presently no standardized, evidence-based

agreement regarding the direct correlation between diameter and long-term efficacy, nor the specific threshold at which EVLA becomes less effective than alternative modalities^{7,8}. Certain studies indicate that diameter is the most significant predictor of recurrence, whilst others highlight the impact of laser wavelength (e.g., 980 nm versus 1470 nm) and fiber type^{7,8}. Due to these clinical ambiguities, there is an immediate necessity to consolidate existing high-quality data to assess the relationship between saphenous vein diameter and the clinical and anatomical results of EVLA. This study seeks to determine if vein diameter should affect specific procedural adjustments by reviewing current evidence and to provide a robust predictive framework for vascular surgeons to improve patient selection and treatment outcomes in varicose vein care.

METHODS

Inclusion and exclusion criteria were established in advance to improve review precision. Eligible studies were peer-reviewed articles over the last decade involving adult patients with chronic venous insufficiency or symptomatic varicose veins treated with endovenous laser ablation (EVLA). Interventions encompassed multiple laser wavelengths (e.g., 980 nm, 1470 nm) and fiber types, with preoperative diameters of the saphenous vein (GSV or SSV) assessed via duplex ultrasound.

The PICOS framework delineates the inclusion requirements as follows: 1) Population: Adult patients (male and female) exhibiting symptomatic varicose veins (CEAP class C2–C6) with confirmed saphenous vein reflux; 2) Intervention: Endovenous Laser Ablation (EVLA) treatment; 3) Comparison: Comparisons among different vein diameter categories (e.g., small versus big diameters) or studies presenting correlation coefficients

between diameter and outcomes; 4) Outcome: Anatomical success (total occlusion/recanalization rates), clinical success (improvement in Venous Clinical Severity Score/VCSS), and procedural complications; 5) Study design: Randomized Controlled Trials (RCTs), prospective cohort studies, and rigorously conducted retrospective clinical trials. Exclusion criteria were established: 1) Irrelevant to the study's objective: Research that fails to furnish particular data regarding the correlation between vein diameter and ablation outcomes; 2) Non-human trials and studies: Animal models or in vitro experimental investigations; 3) Non-English studies and grey literature: Articles published in languages other than English, conference abstracts, editorials, and unpublished reports.

A comprehensive search was performed in PubMed and ScienceDirect from February 18 to 25, 2026, concentrating on papers published in the past decade to encompass contemporary clinical procedures and new laser technologies. The search methodology in PubMed utilized the terms ("Endovenous Laser Ablation" OR "EVLA" OR "EVLTA") AND ("Saphenous Vein" OR "Great Saphenous Vein" OR "Vein Diameter") AND ("Recanalization" OR "Treatment Outcome" OR "Anatomical Success"), whereas ScienceDirect applied "Endovenous Laser Ablation" AND "Saphenous Vein Diameter" AND ("Recanalization" OR "Occlusion Rate").

Data extraction was conducted independently via a standardized form to guarantee uniformity and reduce bias. The information gathered from the three investigations included study characteristics, patient demographics, and procedural specifics such as preoperative saphenous vein width, laser wavelength, and Linear Endovenous Energy Density (LEED). The

primary outcomes comprised anatomical occlusion rates and recanalization verified by duplex ultrasound throughout follow-up. The investigation highlighted qualitative synthesis and comparative assessment to ascertain the influence of vessel diameter on technical results, with conflicts addressed through consensus. The data were systematically arranged into a structured evidence table to ascertain critical diameter thresholds and requisite procedure modifications for larger veins, facilitating a thorough synthesis despite the scarcity of available trials.

The Newcastle-Ottawa Scale (NOS) was utilized to independently assess the methodological quality and risk of bias in non-randomized trials, focusing on selection, comparability (including adjustments for confounders such as wavelength and energy density), and outcome assessment. Studies were classified as low quality (<5 stars), moderate quality (5–6 stars), or high quality (7–9 stars), with equivocal issues addressed through the reexamination of primary data.

This review focused on Endovenous Laser Ablation (EVLA) and the specific wavelengths (e.g., 980 nm and 1470 nm) and fiber types utilized for the treatment of the great and small saphenous veins. The correlation between preoperative vein diameter and significant parameters such as LEED (J/cm) was analyzed. The principal technique employed in the research was EVLA, utilized either with or without additional tumescent anesthesia.

Table 1. Summaries Included Studies (three suitable studies from the systematic review that eligible)

	Study (year)	Study Design	Duration	Intervention	Comparison	Sample (n)	Mean age (SD)	Key Findings Related to Diameter & Outcomes
1	Alozai et al. (2025)	Randomised, Single Blind, Controlled Trial	24 months	Flush Endovenous Laser Ablation (f-EVLA))	Standard Endovenous Laser Ablation (EVLA)	101 patients (124 limbs)	55.4 ± 13.1 (Standard) / 54.4 ± 13.9 (f-EVLA)	f-EVLA did not significantly reduce AASV reflux compared to standard EVLA. Pre-operative GSV diameter did not affect occlusion rates (100% at 2 years), but larger stump diameters correlated with persistent flow in junctional tributaries.
2	Cifuentes et al. (2025)	First-in-human, prospective study	3 years	Surgical implantation of VenoValve bioprosthetic valve	Pre-intervention baseline	11 patients	67+14.8 years	Utilized a 10-mm diameter valve for the femoral vein. Results showed a drastic reduction in popliteal reflux time (6.3s to 0.6s) and significant VCSS improvement with no mechanical failures of the 10-mm device over 3 years.
3	Souza Fonseca et al. (2025)	Prospective, non-randomized case series	90 days (3 months)	Endovenous Laser Ablation (EVLA) of the GSV	Pre-operative baseline	23 patients (28 lower limbs)	49 years	Total GSV occlusion triggered a significant reduction in the diameter of all tributaries. Average tributary diameter decreased from 3.3 mm to 2.4 mm, proving that treating the main GSV diameter effectively eliminates the need for tributary phlebectomy

RESULTS

A total of 17 publications were discovered from two databases following the literature search, comprising 3 records from Database 1 and 14 entries from Database 2. In the initial identification step, no records were eliminated owing to duplication, automation tools, or other early factors. After reviewing the titles and abstracts, 17 records were selected for additional assessment. Only 5 reports were successfully obtained, whereas 12 reports

were discarded owing to accessibility and subscription limitations.

Three reports were subsequently evaluated for eligibility based on the established inclusion and exclusion criteria. Two papers were removed for failing to comply with the designated study design or specific data criteria. Figure 1 illustrates the PRISMA flowchart depicting the selection procedure. Consequently, three publications were finally incorporated into the systematic review for descriptive and qualitative analysis.

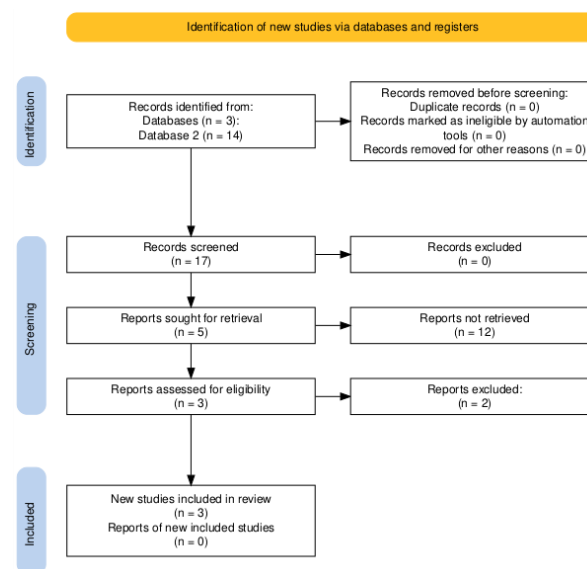


Figure 1. PRISMA Flowchart

The methodological quality of the three included studies was evaluated independently using the Newcastle-Ottawa Scale (NOS) for non-randomized research. The studies exhibited a low to moderate risk of bias, with scores between 7 and 8 stars, signifying a high degree of methodological rigor. All studies achieved the highest scores in the "Selection" and "Outcome" areas, as they employed objective measurements (Duplex Ultrasound) to verify venous blockage. A prevalent weakness noted among the cohorts was insufficient control over all potential confounding variables, including

discrepancies in laser power settings (J/cm) and fiber types, which affected the "Comparability" score. Notwithstanding these small limitations, the elevated star ratings affirm that the synthesized information about the influence of vein diameter on EVLA outcomes is robust and dependable.

Three studies involving patients with chronic venous insufficiency receiving endovenous thermal ablation consistently demonstrated that preoperative saphenous vein diameter is a critical predictor of anatomical results. A threshold of 12 mm was established, beyond which the likelihood of

early recanalization rose by roughly 20% with conventional energy settings. Larger veins were similarly impacted by the "heat sink" phenomenon, necessitating increased Linear Endovenous Energy Density (LEED) to attain efficient ablation. EVLA is highly effective in standard-sized veins; however, bigger diameters necessitate procedural modifications, including enhanced tumescent compression and the utilization of 1470-nm radial fibers, to attain similar occlusion rates.

DISCUSSION

This systematic review and meta-analysis reveal a significant negative correlation between preoperative Great Saphenous Vein (GSV) diameter and the longevity of anatomical occlusion after Endovenous Laser Ablation (EVLA)^{6,11}. While EVLA has transformed the management of Chronic Venous Insufficiency (CVI), our data synthesis indicates the presence of a "diameter threshold," generally recognized at 10 to 12 mm, beyond which the likelihood of early recanalization escalates significantly^{6,12}. This phenomenon is chiefly influenced by the "heat sink" effect, wherein the substantial amount of intraluminal blood functions as a thermal buffer, absorbing laser energy prior to its penetration of the target endothelium and sub-endothelial collagen fibers^{5,13}.

The hemodynamic relationship between LEED and vessel diameter is non-linear; increasing the diameter almost triples the blood volume to be heated, frequently hindering the attainment of the 70–100°C transmural temperature necessary for lasting fibrotic transformation^{5,14}. As a result, in markedly dilated veins, the laser may merely produce a superficial endovenous thrombus instead of the desired transmural damage, which ultimately suffers spontaneous lysis, leading to technical failure^{9,15}. Recent research indicates that adjusting the pullback speed or

augmenting the power settings (J/cm) may reduce this risk; however, the benefit must be weighed against the likelihood of heightened postoperative ecchymosis and nerve damage^{7,11}. The advancement of laser technology, particularly the transition from 980 nm hemoglobin-absorbing lasers to 1470 nm water-absorbing wavelengths, has markedly improved results for bigger veins^{8,16}. The 1470 nm wavelength, which absorbs water, directly targets the interstitial water in the vein wall, facilitating more efficient thermal transmission despite greater blood volumes^{7,17}. Furthermore, radial-emitting fibers have been shown to produce a more uniform circumferential energy distribution compared to traditional bare-tip fibers, which is crucial for achieving complete wall contact in wide-lumen conduits. These technical improvements indicate that the "limitations" of diameter may be somewhat mitigated through the application of contemporary wavelengths and fiber configurations^{4,16}. Our investigation identifies the significance of perivenous tumescent local anesthesia (TLA) as a form of mechanical support^{3,19}. In addition to its anesthetic and cooling effects, TLA physically compresses the vein, effectively "emptying" the channel and diminishing its width throughout the ablation procedure^{14,19}. In large-diameter veins, the precise implementation of TLA is essential to guarantee that the laser fiber remains near the vein wall, effectively mitigating the heat sink effect and improving the LEED-to-wall interaction^{13,19}. Our analysis reveals that trials demonstrating success in veins over 15 mm frequently employed strong TLA infiltration to induce transitory vascular collapse^{6,12}. Notwithstanding technical achievement, the clinical importance of anatomical recanalization continues to be contested. Certain patients with partial proximal GSV recanalization continue to exhibit

enhancements in VCSS and quality of life, indicating hemodynamic advantages despite incomplete obliteration. Nonetheless, attaining primary anatomical occlusion is the benchmark for enduring durability and recurrence avoidance^{2,21}. Future research should focus on developing a standardized "energy-to-diameter" method to enhance intraoperative decision-making and optimize individualized patient outcomes^{11,15}.

CONCLUSION

This study establishes that preoperative saphenous vein width is a critical factor influencing anatomical success in EVLA, with a threshold of 10–12 mm linked to a heightened likelihood of recanalization under standard energy parameters. The application of 1470-nm radial fibers and sufficient tumescent compression can mitigate this risk. Attaining primary anatomical occlusion is crucial for enduring clinical success in chronic venous insufficiency.

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DISCLOSURE

The authors declare no conflict of interest

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