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IMPROVED SAPHENOUS VEIN–PRESERVING ENDOVENOUS LASER ABLATION TECHNIQUE IN THE TREATMENT OF CHRONIC SUPERFICIAL VENOUS INSUFFICIENCY OF THE LOWER EXTREMITIES

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ABSTRACT

Background: Chronic venous insufficiency (CVI) is an advanced stage of chronic venous disease characterized by edema, skin changes, and venous ulceration. The most common etiology is chronic superficial venous insufficiency of the lower extremities involving the great and small saphenous veins. Endovenous laser ablation (EVLA) under ultrasound guidance has been widely applied because of its minimally invasive nature, safety, and high therapeutic efficacy. However, conventional EVLA and surgical techniques commonly destroy or remove the entire saphenous vein. We report the outcomes of a modified ultrasound-guided EVLA technique based on venous mapping, aiming to selectively ablate reflux sites while maximally preserving the saphenous vein.

Case series: Ten patients diagnosed with chronic superficial venous insufficiency of the lower extremities, CEAP class C2–C3, were included based on clinical manifestations and duplex Doppler ultrasound findings. All patients underwent modified ultrasound-guided endovenous intervention using a 1940-nm diode laser system. The procedure targeted only refluxing venous segments identified on venous mapping while preserving unaffected portions of the great saphenous vein.

Results: Clinical symptoms improved markedly from the first postoperative week. Pain, numbness, and edema almost completely resolved, while >90% of varicose veins collapsed. Follow-up duplex Doppler ultrasound demonstrated preserved bilateral great saphenous vein patency in approximately 80% of treated segments without residual reflux. Continued improvement was observed at 6-month and 1-year follow-up visits, with no clinical recurrence recorded. No perioperative complications or major adverse events were observed.

Conclusions: Modified ultrasound-guided EVLA using a 1940-nm diode laser appears to be a safe, effective, and minimally invasive treatment for CEAP C2–C3 chronic superficial venous insufficiency. This technique minimizes pain, bruising, and recovery time while preserving up to 80% of the great saphenous vein without compromising treatment efficacy. It may represent a promising alternative to conventional destructive techniques by reducing operative time, decreasing anesthetic requirements, improving postoperative comfort, and maintaining the saphenous vein as a potential autologous conduit for future coronary or peripheral bypass surgery if needed.

Keywords: Chronic superficial venous insufficiency; Great saphenous vein; Endovenous laser ablation; Ultrasound-guided intervention; Minimally invasive treatment.

1. INTRODUCTION

Chronic venous insufficiency (CVI) is a common vascular disorder and a progressive stage of chronic venous disease (CVD). The prevalence of CVD increases with age and is associated with significant impairment in quality of life and healthcare burden [1,2]. Superficial venous insufficiency involving the great saphenous vein (GSV) is the most common underlying pathology. Venous reflux and venous hypertension may lead to varicose veins, edema, skin changes, and venous ulceration [3,4].

Duplex Doppler ultrasound is currently the gold-standard modality for evaluating chronic venous insufficiency because it allows assessment of venous anatomy, reflux sites, and venous hemodynamics [4]. In recent years, endovenous atioation (EVLA) has progressively replaced conventional stripping surgery as a minimally invasive treatment option because of its high efficacy, reduced postoperative pain, shorter recovery time, and favorable cosmetic outcomes [5–8].

However, conventional EVLA techniques routinely ablate the entire refluxing saphenous trunk regardless of whether reflux originates from localized hemodynamically significant segments or diffuse valvular incompetence. Consequently, functional portions of the great saphenous vein (GSV) are frequently destroyed together with pathological reflux segments. Recently, vein-preserving strategies based on venous hemodynamic concepts and detailed venous mapping have gained increasing attention because selective interruption of pathological reflux pathways may restore venous hemodynamics while preserving the majority of the saphenous trunk [9,10]. The purpose of this report is to describe the clinical outcomes of a modified ultrasound-guided EVLA technique using a 1940-nm diode laser system in patients with CEAP C2–C3 chronic superficial venous insufficiency. Unlike conventional full-length truncal EVLA, this modified technique selectively targets only hemodynamically significant re-

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flux "escape points" identified through detailed duplex venous mapping while preserving the majority of the great saphenous vein.

2. CASE REPORT

This case series included 10 patients diagnosed with chronic superficial venous insufficiency of the lower extremities, aged from 28 to 75 years. . Patients with advanced chronic venous disease (CEAP C4–C6), extensive tortuous truncal reflux requiring complete ablation, or previous deep venous thrombosis were not included in this series.

Among them, two patients had bilateral disease, three patients had right lower extremity involvement, and five patients had left lower extremity involvement. All patients presented with symptoms of calf muscle cramps and leg heaviness, which worsened after prolonged standing during daily activities. Four patients had previously received conservative treatment with Diosmin 500 mg twice daily combined with compression stockings without significant symptomatic improvement.

Clinical examination revealed dilated superficial varicose veins along the medial aspect of the distal thigh and upper to mid-calf regions in seven patients. Four patients presented with soft pitting edema around the lower calf and ankle, while one patient demonstrated skin hyperpigmentation around the malleolar region. No venous ulceration was observed. Peripheral arterial pulses were palpable and no intermittent claudication symptoms were reported.

Duplex Doppler ultrasound demonstrated successful occlusion of the refluxing venous segments with disappearance of pathological reflux flow (<0.5 seconds during provocative maneuvers), while the majority of the great saphenous vein remained patent. No evidence of deep venous thrombosis was identified. Based on clinical and ultrasonographic findings, six patients were classified as CEAP C2 and four patients as CEAP C3 chronic venous insufficiency.

After detailed counseling and informed consent, all patients underwent a modified ultrasound-guided endovenous laser ablation (EVLA) procedure using a 1940-nm diode laser system at the Cardiovascular and Stroke Center, Phuong Dong General Hospital. Preoperative duplex ultrasound venous mapping was performed to identify reflux sites and "escape points," particularly at the saphenofemoral junction and the tributary junction between the great saphenous vein and accessory saphenous vein.

Under sterile conditions and ultrasound guidance, venous access was obtained at the predetermined puncture sites. A laser fiber was introduced into the target venous segments, and tumescent anesthesia was administered around the vein. Unlike conventional EVLA techniques involving continuous full-length truncal ablation, laser energy was selectively delivered only to hemodynamically significant reflux "escape points" identified on preprocedural venous mapping, while intentionally preserving non-refluxing portions of the great saphenous vein trunk. Compression stockings were applied immediately after the procedure, and all patients were able to ambulate shortly after intervention and were discharged on the same day.



Figure 1. Clinical condition of a 50-year-old male farmer with a 10-year history of varicose veins and failed conservative medical treatment before intervention, 1 month after treatment, and 1 year after EVLA

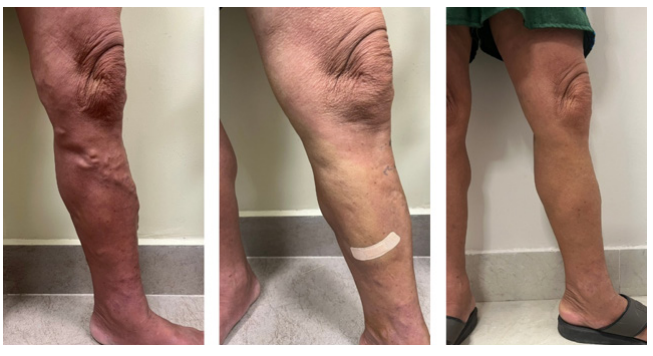


Figure 2. Clinical condition of a 64-year-old male farmer with a history of varicose veins for more than 20 years and failed conservative medical treatment before intervention, immediately after the procedure, and 1 year after EVLA.

The procedure was performed using a 1940-nm diode laser device under duplex ultrasound guidance. Preoperative venous mapping was conducted to identify the reflux "escape points" and determine the target venous segments for selective ablation. Venous access was obtained at the distal great saphenous vein and the laser fiber was advanced to the predetermined reflux point near the saphenofemoral junction while preserving the remaining patent saphenous trunk. Tumescent anesthesia was applied along the target venous segments. A radial fiber was used in all procedures with continuous pullback technique. Mean ablation length was approximately xx cm and the average amount of tumescent anesthesia used was xx mL. Class II compression stockings were prescribed continuously for the first 48 hours and during daytime ambulation for at least 2 weeks after intervention.

Clinical evaluation demonstrated marked improvement immediately after intervention with collapse of the bulging varicose veins and reduction of lower limb edema. No skin burns, thrombophlebitis, nerve injury, or deep vein thrombosis were observed. All patients were able to ambulate shortly after the procedure and were discharged without significant discomfort.

At 1-month and 1-year follow-up visits, clinical symptoms including leg heaviness, pain, muscle cramps, and edema had almost completely resolved. Duplex Doppler ultrasound demonstrated successful occlusion of the refluxing venous segments without residual reflux, while the majority of the great saphenous vein remained patent. No recurrence of visible varicose veins or procedure-related complications was observed during follow-up (Figures 1 and 2).

3. DISCUSSION

Endovenous laser ablation (EVLA) has become one of the standard minimally invasive treatment modalities for chronic superficial venous insufficiency because of its high technical success rate, rapid recovery, favorable cosmetic outcomes, and lower postoperative morbidity compared with conventional stripping surgery [5]. Current international guidelines from the Society for Vascular Surgery (SVS), American Venous Forum (AVF), and American Vein and Lymphatic Society (AVLS) recommend endovenous thermal ablation as a first-line treatment for symptomatic superficial truncal reflux [1][2]. Recent studies using modern radial fibers and higher wavelength laser systems have demonstrated favorable long-term efficacy and safety outcomes [7][8]. The 1940-nm wavelength demonstrates higher absorption by water than earlier generation systems, potentially allowing more controlled thermal injury with lower energy delivery.

Nevertheless, despite major advances in laser wavelength, fiber technology, and procedural safety, the fundamental therapeutic philosophy of conventional EVLA remains largely unchanged: complete thermal destruction of the incompetent saphenous trunk.

The most important distinguishing feature of our case series is that the therapeutic objective was not complete anatomical destruction of the refluxing saphenous trunk, but rather selective hemodynamic correction of pathological venous reflux. Unlike conventional EVLA strategies that routinely ablate the entire incompetent GSV from the saphenofemoral junction to the distal refluxing segment, our modified approach intentionally limited thermal ablation only to hemodynamically significant reflux "escape points" identified through detailed duplex venous mapping. This hemodynamic-oriented strategy differs fundamentally from conventional anatomy-oriented EVLA approaches. Rather than considering the entire saphenous trunk as uniformly pathological, our technique recognizes that clinically significant venous hypertension may originate from localized reflux circuits. Therefore, selective interruption of critical reflux pathways may be sufficient to restore venous hemodynamic balance without complete truncal obliteration.

This concept is increasingly supported by recent literature emphasizing vein-preserving strategies in chronic venous disease management. Ihnatovich et al. discussed the evolving role of multimodal approaches balancing reflux control and preservation of the saphenous trunk, particularly in patients who may later require vascular bypass procedures [10]. Wang et al. demonstrated that targeted tributary laser ablation may achieve favorable clinical outcomes without necessarily requiring complete truncal obliteration [12]. Xu et al. further highlighted the importance of individualized tributary management strategies during endovenous treatment [11]. Utoh et al. demonstrated the feasibility and safety of selective ultrasound-guided laser ablation using slim radial fibers [13]. However, most previous studies focused primarily on adjunctive tributary management combined with standard truncal EVLA, whereas our technique intentionally minimized destruction of the main saphenous trunk itself. This represents one of the most important distinguishing aspects of our case series.

In our patients, clinical improvement was observed immediately after intervention and remained stable throughout follow-up. Symptoms including leg heaviness, pain, muscle cramps, edema, and cosmetic deformity improved markedly, while duplex ultrasound demonstrated elimination of reflux without recurrence during the observation period. Importantly, approximately 80% of the GSV remained patent after treatment. These findings suggest that complete obliteration of the entire GSV may not always be necessary to achieve satisfactory clinical and hemodynamic outcomes in selected CEAP C2–C3 patients.

Another notable aspect of this series is the use of a 1940-nm diode laser system. Yamamoto et al. demonstrated that higher wavelength laser systems produce more localized thermal effects because of increased water absorption [6]. This may reduce collateral tissue injury and postoperative discomfort compared with earlier generation laser devices. Combined with low-energy selective ablation and detailed ultrasound guidance, this may explain the minimal postoperative pain, absence of significant bruising, rapid ambulation, and lack of nerve injury observed in our patients. Utoh et al. also emphasized that modified ablation techniques may contribute to reducing procedure-related nerve injury [14].

Notably, no cases of endothermal heat-induced thrombosis (EHIT), deep venous thrombosis, thrombophlebitis, or skin burns were identified in this series. Kabnick et al. emphasized that EHIT remains one of the most important complications associated with endovenous thermal ablation procedures [15]. Keo et al. also reported that venous thrombosis continues to be a relevant safety concern following EVLA, particularly in patients with additional thrombotic risk factors [16]. The absence of major complications in our patients may reflect the benefits of selective low-energy ablation and limited treatment length.

From a broader perspective, preservation of the GSV may have important long-term implications beyond immediate venous symptom control. The GSV remains the preferred autologous conduit for coronary artery bypass grafting and peripheral arterial reconstruction because of its durability and long-term patency. Conventional stripping or complete EVLA permanently sacrifices this valuable vascular conduit, even in relatively young or cardiovascular high-risk patients who may later require arterial bypass surgery. In contrast, our vein-sparing approach preserves the majority of the saphenous trunk while still providing effective reflux control. This may represent a clinically meaningful advantage that is often underestimated in contemporary venous interventions.

Furthermore, selective EVLA may reduce the total ablation length, amount of tumescent anesthesia, and procedural duration compared with conventional full-length truncal ablation. Reduced thermal exposure may also contribute to improved patient comfort and faster recovery. These characteristics align closely with the current trend toward personalized and hemodynamically oriented treatment strategies in venous disease rather than uniform anatomical destruction.

Despite these promising findings, this report has several limitations. The number of patients remains relatively small, and follow-up duration is still limited compared with long-term studies evaluating recurrence after conventional EVLA. In addition, this case series did not include a direct comparative group treated with standard full-length truncal ablation. Therefore, larger prospective comparative studies are necessary to determine whether selective vein-sparing EVLA can provide durable long-term reflux control comparable to conventional techniques while maintaining the functional integrity of the GSV.

To our knowledge, reports describing selective escape point–oriented EVLA with intentional preservation of the majority of the GSV using a 1940-nm laser system remain limited in the current literature.

Nevertheless, this series demonstrates the feasibility, safety, and potential hemodynamic advantages of selective ultrasound-guided EVLA based on venous mapping. Our

findings suggest that chronic venous insufficiency treatment may not necessarily require complete destruction of the saphenous vein in all patients. Instead, carefully selected reflux-oriented interventions may achieve effective symptom control while preserving venous anatomy and future vascular options.

4. CONCLUSIONS

A case series of chronic venous insufficiency (CVI) with symptomatic varicose veins treated using a modified ultrasound-guided endovenous laser ablation (EVLA) technique has been presented. Unlike conventional EVLA strategies involving complete ablation of the great saphenous vein (GSV), our vein-sparing approach selectively targeted reflux "escape points" identified through venous mapping while preserving the majority of the GSV. The technique demonstrated favorable clinical and ultrasonographic outcomes, with significant symptom improvement, rapid postoperative recovery, minimal postoperative discomfort, and no major complications during follow-up. Preservation of the GSV may provide additional long-term benefits by maintaining a potential autologous conduit for future bypass surgery. This modified EVLA technique may represent a promising minimally invasive alternative to conventional destructive approaches for selected CEAP C2–C3 patients.

5. LIMITATION

In addition, objective venous severity scores and quality-of-life measurements such as VCSS or AVVQ were not systematically collected in this preliminary series.

Patient consent

Written informed consent was obtained from all patients for publication of this case series and the accompanying clinical images.

Ethical approval was waived because this study was a descriptive retrospective case series using anonymized patient data and standard clinical procedures.

6. Data availability

Underlying data

All data underlying the results are available as part of the article, and no additional source data are required.

7. ACKNOWLEDGEMENTS

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