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Endovenous Laser Ablation with 1064 nm and 1470 nm Lasers: A Comparative Study

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ABSTRACT

Endovenous laser ablation (EVLA) is an established treatment for chronic venous disease, although the role of laser wavelength in clinical outcomes remains uncertain. This single-center retrospective study compared EVLA performed with a 1470 nm diode laser and a 1064 nm Nd:YAG laser in 100 consecutive patients treated between October 2022 and January 2023. The primary outcome was complete occlusion of the treated truncal vein at 3 months on duplex ultrasound. Occlusion was achieved in 24/25 patients (96.0%) in the 1470 nm group and 74/75 patients (98.7%) in the 1064 nm group. Follow-up was performed at 3 months and 1 year. No major complications were observed. In the 1470 nm group, one superficial vein thrombosis and one mild localized inflammation were recorded; no complications were recorded in the 1064 nm group. Both treatment approaches were associated with high occlusion rates and a favorable safety profile. Prospective studies are needed to clarify the independent effect of wavelength on EVLA outcomes.

Key words: Endovenous Laser Ablation, EVLA, Varicose Veins, 1064 nm Nd:YAG Laser, 1470 nm Diode Laser

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I. INTRODUCTION

Affecting up to 60% of the adult population[1], chronic venous disease of the legs is a common condition caused by malfunctioning veins. Historically, surgical high ligation and stripping has been the standard treatment for varicose veins, however, contemporary guidelines now recommend less invasive endovenous techniques as a first-line therapy.[1] These include thermal ablation, cyanoacrylate adhesive closure, and mechanochemical ablation.[1] Endovenous laser ablation (EVLA) is a well-established minimally invasive technique that achieves high occlusion rates while reducing recovery time and complication risk compared with surgery.[1,2]

The procedure requires duplex ultrasound localization for endovenous insertion and direct visual monitoring of the device during treatment.[3] Perivenous tumescent anesthesia is administered under ultrasound guidance to provide analgesia, compress the vein to improve fiber–wall contact, and create a thermal barrier that limits heat transmission to surrounding tissues during laser activation.[4] Endovenous laser ablation achieves vein closure by delivering thermal energy to the vein wall, inducing endothelial damage, collagen contraction, and subsequent fibrosis[5]. Treatment efficacy depends on multiple procedural factors, including wavelength, fiber design, pullback technique, delivered energy, and the quality of tumescent anesthesia.[6–8]

Over time, EVLA technology has evolved through the use of different laser wavelengths, which are directly linked to the target chromophores. Early systems employed shorter wavelengths (for example, 810 nm), which predominantly target hemoglobin, resulting in greater intraluminal blood absorption and secondary heat transfer to the vein wall.[7,8] On the other hand, newer generations of systems utilize longer, water-specific wavelengths such as 1320 nm and 1470 nm that deposit a greater proportion of energy in water-rich tissues, such as the vein wall.

The shift toward higher water absorption has been associated with more controlled thermal injury while maintaining high technical success and vein occlusion rates.[5] Moreover, comparative evidence suggests that higher water-absorbing wavelengths, may further enhance efficacy and safety by producing more uniform vein wall damage compared with earlier hemoglobin-targeting systems.[9]

However, despite the technological shift toward water-specific wavelengths and accumulating comparative data, the precise impact of wavelength on EVLA efficacy and safety remains incompletely understood, as outcomes may be confounded by factors such as fiber type, linear endovenous energy density (LEED), and vein characteristics.

II. AIM

This study aimed to compare short-term efficacy and safety outcomes of EVLA performed with a 1470 nm diode laser and a 1064 nm Nd:YAG laser in routine clinical practice.

III. MATERIALS AND METHODS

a) Study design

A single-center retrospective observational study was conducted, including 100 consecutive patients undergoing EVLA of truncal superficial venous insufficiency. The patients were treated between October 2022 and January 2023. Treatment allocation was non-randomized and determined by device availability.

- Group A (1470 nm): 25 patients (26 treated segments)
- Group B (1064 nm): 75 patients (83 treated segments).

b) Procedure technique

All procedures were performed in an ambulatory setting under duplex ultrasound guidance with local tumescent anesthesia. A 600 μm bare-tip fiber was used in all cases. Standard positioning relative to the saphenofemoral or saphenopopliteal junction was applied, and early ambulation was encouraged.

Devices used:

- 1470 nm diode laser system (SkyWave, Fotona, Slovenia)
- 1064 nm Nd:YAG laser system (SP Dynamis, Fotona, Slovenia)

c) Tumescent anesthesia

A standardized perivenous tumescent technique under ultrasound guidance was used, aiming for circumferential infiltration along the treated segment to provide analgesia, hydrodissection, and vein compression. Injected volume was adjusted according to treated length and intraoperative conditions.

d) Perioperative management

- Postprocedural thromboprophylaxis with nadroparin calcium (Fraxiparine) was administered for 1 week: 0.4 mL for patients ≤70 kg and 0.6 mL for patients >70 kg.
- Compression therapy was prescribed for 4 weeks (class II). Thigh-high stockings with a waist attachment were used in most patients; knee-high stockings were used in VSP cases.

e) Statistical Analysis

Continuous variables were summarized as median and interquartile range (IQR). Normality was assessed using the Shapiro–Wilk test. Non-parametric comparisons were performed using the Mann–Whitney U test. Categorical variables were compared using Fisher's exact test. LEED was calculated per treated vein segment. Vein types were reported descriptively but were not formally compared between groups because of the small number of cases in individual categories and incomplete documentation of vein diameter. Analysis of LEED was performed at the level of treated segments without adjustment for within-patient clustering.

f) Outcomes and follow-up

Follow up visits including clinical evaluation and duplex ultrasound were performed at 3 months and 1 year. Additional investigations were not performed unless clinically indicated. The primary outcome was complete occlusion of the treated truncal vein, defined as absence of a compressible lumen and absence of flow on duplex ultrasound at 3 months and 1 year. Safety outcomes included deep vein thrombosis (DVT), endovenous heat-induced thrombosis (EHIT), nerve injury, skin burns, and procedure-related hospitalization and treatment-related discomfort.

Pain/discomfort was assessed by direct verbal inquiry without use of a validated scale and was not systematically recorded; therefore, these data were not included in formal analysis.

g) Laser parameters and energy reporting

Laser system logs were retrospectively reviewed to extract treatment parameters, including wavelength, nominal power, pulse characteristics, and total exposure time. Total delivered energy per treated segment was calculated based on recorded power and exposure duration, and expressed as linear endovenous energy density (LEED).

Table 1. Prespecified treatment parameters for each protocol

Device	SkyWave, Fotona, Slovenia	SP Dynamis, Fotona, Slovenia
Wavelength	1470 nm diode laser	1064 nm Nd:YAG laser
Power	10 W	25 W
Pulse mode	Pulsed, 25 ms, 20/25 Hz	QCW (quasi-continuous wave), 0.3 ms, 100 Hz
LEED (linear endovascular energy density)	60-80 J/cm	100 J/cm

IV. RESULTS

a) Study Population and Baseline Characteristics

A total of 100 patients undergoing 109 EVLA procedures were included. Group A (1470 nm) included 25 patients (26 treated segments), and Group B (1064 nm) included 75 patients (83 treated segments).

Baseline characteristics in both groups were similar with respect to age, sex, and treated segment length. Groups were age-matched (group A (1470 nm): median 54.0 years; Group B (1064 nm): median 55.0 years; Mann–Whitney U test; $p = 0.419$).

Sex distribution between groups was comparable (Group A (1470 nm): 9 M and 16 F; Group B (1064 nm): 21 M and 54 F, Fisher's exact test: $p = 0.460$).

Median treated segment length was also similar between groups (Group A (1470 nm): 23 cm; Group B (1064 nm): 25 cm; Mann–Whitney U test, $p = 0.72$).

A range of truncal veins were treated in both groups, including great saphenous, small saphenous, and anterior accessory saphenous veins.

b) Efficacy

At 3 months, complete occlusion was documented in 74/75 treated patients (82/83 segments) in the 1064 nm group and 24/25 treated patients (25/26 segments) in the 1470 nm group. No changes at 1 year follow-up.

One case in the 1470 nm group showed persistent patency of an anterior accessory saphenous vein at 3 months and was treated with adjunctive foam sclerotherapy with 2% Aethoxysklerol (lauromacrogol 400); occlusion was confirmed at 1 year.

One case in the 1064 nm group showed a partially residual great saphenous vein segment (approximately 10 cm, small vein ~4 mm) without flow or reflux. The segment was considered clinically occluded.

c) Safety

Safety outcomes were evaluated over a 1-year follow-up period. No major complications were observed in either group. Specifically, no cases of DVT, EHIT, nerve injury, skin burn, or procedure-related hospitalization occurred. Minor adverse events occurred only in the 1470 nm group.

One patient in the 1470 nm group experienced mild localized inflammation in the distal part of the obliterated vein (Figure 1). This resolved spontaneously within one week.

One case of superficial vein thrombosis occurred 1 week after 1470 nm EVLA.

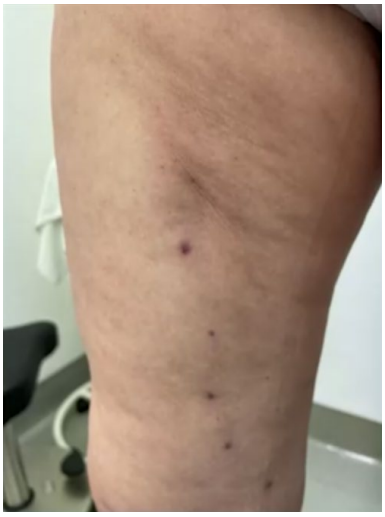

Figure 1: Mild inflammation case in Group A.

No complications were recorded in the 1064 nm group.

d) Delivered energy

Median LEED was significantly higher in the 1064 nm group compared with the 1470 nm group (115.9 J/cm [IQR 109.4–131.4] vs 82.0 J/cm [IQR 74.2–94.9]; $p < 0.001$), (Mann–Whitney U test = 2102.5, $p < 0.001$). This difference reflects predefined treatment protocols (Table 2).

Table 2: Treatment parameters and delivered energy.

	Group A	Group B
Wavelength	1470 nm diode laser	1064 nm Nd:YAG laser
Median LEED IQR	82.0 J/cm, 74.23 – 94.87 J/cm	115.9 J/cm, 109.41 – 131.40 J/cm

LEED – linear endovascular energy density.

e) Qualitative procedural observations

Qualitative intraoperative and postoperative observations were recorded without validated scale and are therefore reported descriptively only.

Patients treated with 1470 nm reported less discomfort during intraoperative verbal inquiry. However, greater postoperative discomfort was noted in the 1470 nm group at the 3-month follow up appointment. Patients treated with 1064 nm occasionally reported a transient metallic or burnt taste during the procedure, a phenomenon previously described in the literature.[10]

f) Highlighted clinical case

A selected case is presented as an example of successful treatment. However, it does not contribute to comparative analysis.

A 60-year-old female patient with a 3-year history of ulceration presented to the clinic (Figure 2 left). GSV was treated with 1470 nm laser, and the ulcer healed successfully (Figure 2 right).

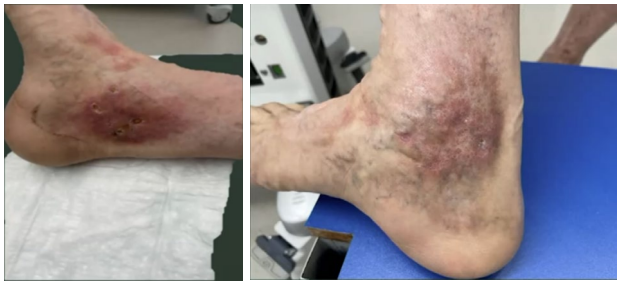

Figure 2: Highlighted clinical case: Before the treatment (left) and 3 weeks after the treatment (right).

V. DISCUSSION

This study provides real-world data comparing EVLA performed with 1470 nm and 1064 nm laser systems, demonstrating that both approaches achieve high occlusion rates and a favorable safety profile.

Baseline similarity in age, sex, and treated segment length allows a descriptive comparison between groups. Additionally, both groups used the same fiber type, which has been identified as an important determinant of treatment outcomes[11]. Nevertheless, the present dataset does not allow superior safety claims for any of the two used wavelengths, but the data contribute evidence to support the known favorable safety profile of EVLA.

Published experience with 1064 nm Nd:YAG EVLA reports high closure rates and favorable safety[10], consistent with the present findings of 98.7 % occlusion rate at 1 year follow-up with Nd:YAG. Similarly, our data demonstrates high closure rates (96.2 %) at 1-year follow-up with 1470 nm EVLA, in line with published meta-analytic evidence demonstrating durable occlusion rates exceeding 90 % at mid-term follow-up.[9]

Importantly, median LEED was significantly lower in the 1470 nm group compared to the 1064 nm group, reflecting the differences in protocols, which were defined according to wavelength–tissue interaction and energy requirements.

Several different wavelengths are used for EVLA and the reviews usually group them according to lower (<1000 nm) or higher (>1000 nm) wavelengths. Mechanistically, known wavelength–tissue interactions link lower wavelengths (for example 810 nm) to a hemoglobin target, and rely more on intraluminal blood absorption and heat transfer. On the other hand, higher wavelengths (for example 1320 nm and 1470 nm) are water-specific and concentrate heating closer to the vein wall.[7,8] Previously published experimental and clinical data suggest that higher water affinity is associated with more uniform vein wall damage and improved selectivity of thermal injury.[9]

1064 nm exhibits mixed absorption characteristics, interacting with both hemoglobin and water, resulting in a combined mechanism of intraluminal and vein wall heating. The higher LEED observed in the 1064 nm group reflects predefined treatment protocols. These protocols are based on known wavelength–tissue interaction characteristics.[7,8]

Comparative literature (often involving 980 nm vs 1470 nm) generally reports similar occlusion rates, with differences more often observed in patient-reported recovery or safety outcomes.[6,11]

In the present dataset, intraoperative discomfort was recorded qualitatively without a validated scale; therefore, the observation of lower reported intraoperative discomfort and higher postoperative discomfort with 1470 nm should be interpreted as hypothesis-generating only.

Earlier EVLA literature linked low energy dosing to recanalization risk, supporting transparent reporting of exposure time and delivered energy.[12] Both wavelengths were associated with high occlusion rates despite different median LEED, suggesting that effective treatment can be achieved across a range of energy settings when appropriate treatment protocols are applied. Similarly, systematic review evidence suggests that within commonly used ranges, many EVLA parameters may have limited influence on efficacy, emphasizing the need for technique standardization and adequate tumescent anesthesia[13].

a) Limitations

Limitations include retrospective design, non-randomized allocation based on device availability, qualitative intra- and post-operative discomfort assessment without a validated scale and documentation, no adjustment for within-patient clustering, unequal group sizes, lack of vein diameter data, lack of baseline severity measures (e.g., CEAP) and additional covariates (e.g., BMI, comorbidities). Formal comparison of complication rates is limited by small event counts.

Ethics and consent

The study was conducted in accordance with the Declaration of Helsinki. In accordance with national regulations, formal ethics committee approval was not required due to the observational and retrospective nature of the study. Written informed consent for treatment and for the use of anonymized clinical data for scientific publication was obtained from all patients.

VI. CONCLUSIONS

EVLA performed with both 1064 nm and 1470 nm laser systems was associated with high occlusion rates and a favorable safety profile in this single-center retrospective cohort. Prospective studies with balanced groups, standardized pain assessment, and adjustment for procedural confounders are needed to clarify the independent effect of wavelength on outcomes.

Authors contributions

Klarič designed the study. Klarič and Premrl conducted the treatments and collected the data. Kozak and Prša drafted the manuscript. Kozak and Prša were not involved in study design or data collection. The authors declare no competing interests. All authors reviewed and approved the final manuscript.

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