A comparison between two different linear endovenous energy density (LEED) for great saphenous vein ablation using 1470-nm diode laser

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Abstract

Introduction: The immediate success rate of endovenous occlusion of the great saphenous vein (GSV) and its durability after endovenous laser ablation (EVLA) was postulated to be the matter of a dose-response relationship to the amount of laser energy used.

Patients and methods: Patients presenting with varicose veins with incompetent GSV scheduled for EVLA were randomized into Group A who received low linear endovenous energy density (low LEED), and group B who received high linear endovenous energy density (High LEED) using the new 1470-nm diode laser. Patients were followed up for 6 months for the durability of GSV occlusion and the occurrence of unwanted side effects after the procedure.

Results: Between April 2011 and May 2012, we treated 63 legs in 58 patients. We had no statistically significant difference between the two groups regarding the occurrence of early post-operative side effects as pain, paraesthesia, and ecchymosis.

Regarding ultrasound proven durability of GSV occlusion after 6 months, data showed total occlusion of the treated GSV segment in 24 out of 32(75%) legs in group A versus 30 out of 31(96.7%) legs in group B. This data indicates a statistically significant difference (P= 0.04) regarding the failure of treatment in the treated GSV segment in group A patients who had the Low LEED 35J/cm in comparison to group B patients who had the High LEED 50J/cm.

Conclusion: The use of the 1470-nm diode laser radial fiber (ELVeS-radial kit) with a high laser energy dose (LEED 50J/cm) was optimum in achieving a durable GSV occlusion without a significant increase in unwanted side effects when compared to lower laser energy dose (LEED 35J/cm).

Key words: Diode laser, great saphenous vein, laser ablation, LEED.

Introduction:

Approximately one-third of men and women aged 18 to 64 years have varicose veins.[1]

During recent years, endoluminal treatment modalities have evolved for the thermal ablation of the incompetent great saphenous vein (GSV). In the last decade, the spectrum of treatment for varicose veins has been broadened. New, less invasive treatment options than surgery have been introduced, such as ultrasound-guided foam sclerotherapy, radiofrequency ablation, and endovenous laser ablation (EVLA).

Soon after the introduction of the endovenous radiofrequency closure technique,[2] endovenous laser ablation (EVLA) of the GSV was presented, initially using the haemoglobin specific wavelength diode lasers with 810-nm, 940-nm, 980-nm, and 1064-nm wavelengths. This was followed by the introduction of the water specific wavelength 1320-nm laser and finally the new generation laser with a longer wavelength of

1470-nm. Some have hypothesized that the 1470-nm laser efficacy would be higher due to higher specificity for the interstitial water in the vessel wall and lower absorption by hemoglobin.[3-5]

From the very beginning, the immediate success rate of endovenous occlusion of the GSV and its durability were in the focus. Soon it became apparent that, particularly after EVLA, recanalization of initially occluded GSVs is a relevant process that starts immediately thereafter.[6,7] Multiple regression analysis of a prospectively obtained set of clinical data finally suggested that as soon as 3 months after laser treatment, there might be a dose-response relationship between laser energy and a persistent occlusion of the GSV.[8]

Numerous randomized controlled trials (RCTs) and observational studies have compared the efficacy of endovenous laser ablation to surgery, sclerotherapy and radiofrequency ablation procedures, but to our knowledge, few studies have triggered the issue of dose-response relationship between linear endovenous energy density (LEED) applied to the vein wall using different laser wavelengths and a persistent occlusion of the GSV.

LEED is best defined as the number of joules delivered per centimeter of the target vein during an EVLA procedure. Efficacy has been the primary endpoint of LEED studies, evaluating low LEED versus high LEED. In initial studies, Timperman et al[9,10] determined that energy doses > 80 J/cm produced more efficacious results than LEED < 80 J/cm, with no difference in side effects. Similarly, another study concluded that LEED was the main determinant in the success of EVLA, with the greatest efficacy occurring at an LEED > 60 J/cm.[11] Pannier et al[12] evaluated a 1470-nm laser, reporting a 100% success rate with an average LEED of 107 J/cm for great saphenous vein treatment. It was noted that in the limbs which received a LEED > 100 J/cm, there was a considerably higher incidence of paraesthesia (15.5%) than limbs receiving < 100 J/cm (2.3%). The data from these studies suggest that the optimal LEED is in the range of 60 J/cm to 100 J/cm.[9-12]

In this study, and with our intention to reach the lowest amount of energy needed to obtain a durable GSV occlusion with the least postoperative unwanted side effects, we prospectively followed up 2 different cohorts of patients for 6 months treated by 2 different linear endovenous energy density (LEED) using the 1470-nm diode laser radial fiber (ELVeS-radial kit) to compare the effect of these 2 different LEEDs on recanalization rates as well as the occurrence of unwanted complications.

Patients and methods:

Our prospective, randomized study included consecutive patients who underwent EVLA of incompetent varicose veins. All patients who presented to our vascular surgery unit, with symptoms suggestive of symptomatic varicose veins, had their baseline examination including history, physical examination, and venous duplex ultrasound imaging of the lower extremity veins, then randomized into 2 groups. Group A patients received low LEED, and group B patients received high LEED.

Inclusion criteria for the study were patients with varicose veins of clinical stage C2 or higher according to CEAP classification, and functional testing by duplex scanning showing an incompetent GSV with reflux of more than 500 milliseconds after the Valsalva maneuver or manual augmentation with or without varicose tributaries necessitating phlebectomies. We excluded patients from EVLA treatment if the average size of the varicose vein was >12mm or if there was extreme tortuosity of the GSV. All patients gave informed consent for the procedure.

Venous ultrasound imaging during the procedure was performed using (SonoAce PICO, linear probe, HL5-9ED 7.5MHz/40mm Medison Co., Seoul, Korea).

The ELVeS-radial kit 1470-nm diode laser (Cerelas D, Biolitec, Germany) consists of a 600 µm radial fiber with guidance markings, a 6 Fr sheath with 12 cm introducer length, a 0.038 J-tip guide wire with 45 cm length, and a 19G - 7 cm entry needle. The radial fiber releases its energy in a 360° manner from a

nontraumatic fiber tip. The entire procedure was guided by venous ultrasound imaging.

The GSV was punctured with duplex guidance at below the knee level with the 19G needle followed by introduction of the 0.038 J-tip guide wire then the 6Fr sheath. Then placement of the laser fibers was performed through the sheath up to a level 2cm distal to the saphenofemoral junction (SFJ) under ultrasound guidance. A tumescent local anesthesia was given consisting of 25 mL of 2% Lidocaine, and 20 mL of sodium carbonate, diluted in 500 mL of saline along the perivenous space with the use of ultrasound guidance. Laser energy was delivered at 7W with LEED 35J/cm for group A patients, and at 10W with LEED 50J/cm for group B patients using the radial fiber with a continuous pullback speed of 1cm/5 seconds. The pullback was guided by the graduated laser fiber shaft with markers at 1cm intervals along the fiber shaft. The GSV was treated from 2cm distal to the SFJ to approximately 1 cm above the skin entry site.

After the procedure, venous outflow was checked immediately in the proximal deep veins by ultrasound imaging, and additional treatment with mini phlebectomies in the leg using a Varady phlebectomy hook (Varady FB122, Aesculap) was applied if needed.

Immediately after the procedure, prophylaxis of venous thromboembolism with subcutaneous enoxaparin (40 mg) was given once. Compression therapy with a graduated class II stocking at 30 to 40 mm Hg was initiated immediately. Patients were to wear the stockings for 24 hours for 1 week, then during the day for another week. Diclofenac potassium (Cataflam), a nonsteroidal anti-inflammatory drug was prescribed (50 mg, twice daily) for 7 days. The patient was told to resume routine daily activities immediately but to avoid strenuous exercise for about 1 week.

Follow-up examinations were performed at 1 week, 3 months, and 6 months after laser therapy and included clinical examination for pain, paraesthesia, signs of ecchymosis and venous ultrasound imaging to examine the treated vein for recanalization and also to exclude deep vein thrombosis (DVT) in the leg.

Study end points. The primary study end points were the occurrence of pain, paraesthesia, and ecchymosis in the early postoperative period and ultrasound proven elimination of venous flow in the treated GSV segment after 6 months.

The distance from the saphenofemoral junction to the beginning of the occluded vein segment was measured, and if this distance exceeded 3 cm or if any part of the treated GSV showed flow signals on augmentation or Valsalva maneuver, then the GSV was judged recanalized. If recanalization did not affect the entire length of the treated GSV, then the recanalization was termed partial recanalization.

Statistical analysis: Differences between the study groups were compared by Chi square ($\chi 2$) test for categorical variables, and *student's T test* for continuous variables. Values of $P < 0.05$ were considered significant.

Results:

Between April 2011 and May 2012, we treated 63 legs in 58 patients with the ELVeS-radial kit 1470-nm diode laser (Cerelas D, Biolitec, Germany). Procedures in patients who required bilateral treatment were performed at different sessions with a time interval of 4 weeks. The baseline characteristics of both groups are reported in **Table(1)**. We had 58 patients (38 females, 65.5% and 20 males, 34.5%) with a mean age of 39.7±11.9 years. Forty eight legs had symptomatic varicose veins, with or without edema (C2-C3), and fifteen legs had skin changes with or without venous ulcers (C4-C6). Etiology was primary superficial valvular incompetence in all patients. Pre-procedure deep venous reflux and/or perforator reflux was detected in 15 legs (23.8%); the detected deep venous reflux was negligible. Great saphenous vein (GSV) diameter mean was 7.7 +/-2.0 mm (range, 4 to 12 mm) for both groups. The cohorts showed no statistically significant differences in age, sex, clinical presentation, and GSV diameter before the treatments, as described in **Table(1)**.

Table (1): Demographic data and clinical presentation.

	Group A (low LEED)	Group B (high LEED)	P value
Number of patients	28	30	
Number of legs treated	32	31	
Male:Female (n)	8:20	12:18	P=0.36
Age (years,mean±SD)	39.8±11.9	39.6±12.1	P=0.95
Clinical presentation C2-3 (n,%)	25 (78.1%)	23 (74.2%)	P=0.71
Clinical presentation C4-6 (n,%)	7 (21.9%)	8 (25.8%)	
GSV diameter(mean±SD	7.8±1.95	7.6 ± 2.1	P=0.61

LEED, linear endovenous energy density; GSV, great saphenous vein; n, number; SD, standard deviation.

We didn't have any of our patients in both groups lost for follow up as they were contacted by phone at time of follow up and we did not have any refusals for follow up. Thus, the 6-month follow-up data could be completed in 63 of 63 limbs (100%). We did not have any cases of DVT in both groups as proved by duplex scan throughout the follow up period.

Regarding our study end points, we had no statistically significant difference between the two groups regarding the occurrence of early post-operative side effects. Early post-operative pain occurred in 3(9.4%) legs in group A versus 4(12.9%) legs in group B (p=0.65). None of our patients in both study groups experienced paraesthesia in the post-operative period. We had 2(6.3%) legs in group A, who had post-operative ecchymosis versus 7(22.6%) legs in group B (p=0.06) which was nearly, yet not statistically significant as shown in **Table(2)**.

Our results regarding ultrasound proven elimination of venous flow in the treated GSV after 6 months showed, total occlusion of the treated GSV segment in 24 out of 32(75%) legs in group A versus 30 out of 31(96.7%) legs in group B, while there was partial recanalization in the treated GSV segment in 5(15.6%) legs in group A versus 1(3.2%) leg in group B, and complete recanalization in the treated GSV segment in 3(9.4%) legs in group A versus 0(0%) legs in group B. This data showed a statistically significant difference regarding the failure of treatment in the treated GSV segment between both groups with a P value of (P= 0.04) which indicates a higher failure rate in group A patients who had the Low LEED 35J/cm in comparison to group B patients who had the High LEED 50J/cm as shown in **Table(2)**.

Table (2): Outcomes after ELVeS-radial kit 1470-nm diode laser treatment.

	Group A (low LEED)	Group B (high LEED)	P value
Number of legs	32	31	
Postoperative pain (n,%)	3 (9.4%)	4 (12.9%)	P=0.65
Postoperative paraesthesia (n,%)	0 (0%)	0 (0%)	------
Postoperative ecchymosis (n,%)	2 (6.3%)	7 (22.6%)	P=0.06
GSV total occlusion at 6 months (n,%)	24 (75%)	30 (96.7%)	P=0.04
GSV partial recanalization at 6 months (n,%)	5 (15.6%)	1 (3.2%)	
GSV complete recanalization at 6 months (n,%)	3 (9.4%)	0 (0%)	

GSV, great saphenous vein; n, number

Discussion:

Apart from the study by Proebstle et al[13] using the 910-nm diode laser in which energy is known to be absorbed by deoxygenated hemoglobin, no contemporary definition was postulated to the amount of linear endovenous energy density (LEED) needed by the new 1470-nm diode laser which acts directly on the vessel wall through the absorption by the interstitial water with its lately developed radial fiber that emits light at 360°, causing a homogenous alteration of the vein wall.

Previous studies conducted using different types of diode laser showed that the LEED below the target range led to failure of GSV occlusion, whereas, high LEED demonstrated increased side effects of the procedure.[9-12]

Proebstle et al[13] postulated that the energy dose LEED is the crucial parameter in determining the balance between achieving durable GSV occlusion and the occurrence of post-operative side effects.

In our study, we confined our patient selection to those with GSV diameter ranging between 4-12mm, which is the range in which the majority of our patients fall, in order to exclude those with too large GSV diameters who will possibly require high energy dose than the usual dose needed for the majority of patients.

For the purpose of comparing our two patients' groups regarding the post-operative ecchymosis related to the GSV laser treatment, we excluded patients who needed phlebectomies in the thigh region to avoid the conflict of whether the ecchymosis was due to the laser dose applied to the GSV or to the phlebectomies procedure.

This study demonstrates that for GSV diameters between 4 and 12mm, the application of LEED of 50J/cm was associated with a significant higher GSV occlusion rate without a significant increase in unwanted side effects as pain, paraesthesia, and ecchymosis. Also the use of the LEED of 50J/cm was associated with a durable GSV occlusion rate of 96.7% which was comparable to other studies using higher energy doses in the range of 60 J/cm to 100 J/cm.[9-12] Whereas the use of LEED of 35J/cm was associated with a nonsignificant lower rate of unwanted side effects yet with a significantly higher rate of GSV recanalization.

Conclusion:

In this study we concluded that the use of the 1470-nm diode laser radial fiber (ELVeS-radial kit) with a LEED of 50J/cm at 10 Watts for GSV diameters between 4-12mm, was optimum in achieving a durable GSV occlusion comparable to higher laser energy doses without a significant increase in unwanted side effects when compared to lower laser energy doses.

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