Varicose Vein Treatment With Endovenous Laser Therapy

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Overview

Chronic venous disorders (CVDs) of the lower extremity are common problems caused by venous hypertension, which is commonly the result of reflux in one or more of the saphenous veins and their primary tributaries. Treatment options in patients with saphenous vein incompetence include conservative management or elimination of these incompetent pathways using endovenous techniques or surgery.

Although conservative management with compression therapy may improve the symptoms of chronic venous insufficiency, it does not cure it. Historically, surgery was considered the best way to eliminate incompetence using ligation of the saphenous vein at its deep vein junction and removal of the abnormal saphenous vein segments; this procedure is known as high ligation and stripping (HL/S). Over the last 10-15 years, HL/S has been essentially replaced by percutaneous endovenous thermal ablation. Two types of thermal ablation procedures exist: endovenous laser ablation (ELA) and radiofrequency ablation (RFA). Both procedures are associated with high success and low complication rates. The procedures are generally performed on an ambulatory basis with local anesthetic and typically require no sedation. The patients are fully ambulatory following treatment, and the recovery time is short. In this article, ELA is reviewed in detail.

ELA mechanism of action

The underlying goal for all thermal ablation procedures is to deliver sufficient thermal energy to the wall of an incompetent vein segment to produce irreversible occlusion, fibrosis, and ultimately disappearance of the vein. The mechanism of vein wall injury after ELA is controversial. It has been postulated to be mediated both by direct effect and indirectly via laser-induced steam generated by the heating of small amounts of blood within the vein. Adequately damaging the vein wall with thermal energy is imperative to obtain effective ablation. Some heating may occur by direct absorption of photon energy (radiation) by the vein wall, as well as by convection from steam bubbles and conduction from heated blood. However, these later mechanisms are unlikely to account for most of the impact on the vein.

Diode lasers are most commonly used for ELA. Laser generators exist with multiple different wavelengths, including lower wavelengths that are considered hemoglobin specific and include 810 nm, 940 nm, 980 nm, and 1064 nm. Higher wavelengths are considered water specific and include 1320 nm and 1470 nm. Although it is still not definitively established in the literature, some authors suggest that the higher wavelength lasers produce similar efficacy at lower power settings with less postprocedure symptoms.
It can be performed with multiple different laser fiber designs (ie, bare-tip fibers, jacket-tip fibers [see image below], radial fibers) and diameters available from a variety of vendors. Each of the fiber designs has been demonstrated to be effective in closing the saphenous vein. At this point, there are no conclusive data demonstrating a superiority of a given fiber, wavelength and energy deposition combination, efficacy, significant adverse effects, or complications as metrics for comparison.

![Picture of a jacket-tip laser fiber. Courtesy of AngioDynamics (http://www.angiodynamics.com/).](image)

**Target veins**

ELA has been successfully and safely used to ablate the great and small saphenous veins, the anterior and posterior accessory great saphenous vein, the superficial accessory saphenous vein, the anterior and posterior circumflex veins of the thigh as well as the thigh extension of the small saphenous vein, including the vein of Giacomini.

ELA has been used to treat long straight competent tributary veins outside the superficial fascia, particularly in patients who are obese and who either sclerotherapy or microphlebectomy would be difficult, time consuming, or prone to side effects.[3]

**Indications**

The selection of candidates for ELA involves a directed history, physical examination, and duplex ultrasound (DUS) examination. The details of the clinical and DUS examination have been discussed in other chapters. Indications for endovenous treatment are listed below.

Symptoms affecting quality of life are as follows:

- Aching
- Throbbing
- Heaviness
- Fatigue
- Restlessness
- Night cramps
- Pruritus
- Spontaneous hemorrhage

Skin changes associated with chronic venous hypertension are as follows:

- Corona phlebectasia, eczema, and pigmentation
• Lipodermatosclerosis
• Atrophie blanche
• Healed or active ulceration
• Edema
• Superficial phlebitis (SVT) in varicose veins

Cosmetic (restorative) concerns are indications for treatment.

Anatomical indications are as follows:

• Significant reflux documented on DUS examination (reflux >0.5 seconds)
• Straight vein segment
• Intrafascial or epifascial vein segment meeting other anatomical criteria that can be pushed away from the skin with tumescent anesthetic
• Reflux responsible for venous hypertension leading to the clinical abnormalities

Contraindications

The contraindications to endovenous treatment are listed below.

• Patients who are pregnant or breastfeeding (concerns related to anesthetic use and heated blood effluent that may pass through the placenta to the fetus)
• Obstructed deep venous system inadequate to support venous return after ELA
• Liver dysfunction or allergy making it impossible to use a local anesthetic (cold saline may be useful as an alternative)
• Allergy to both amide and ester local anesthetics (cold saline may be an alternative)
• Severe uncorrectable coagulopathy (ELA is safe with warfarin use if the international normalized ratio is between 2 and 3.\textsuperscript{4])
• Severe hypercoagulability syndromes (where risk of treatment outweighs potential benefits despite prophylactic anticoagulants)
• Inability to adequately ambulate after the procedure
• Sciatic vein reflux
• Thrombus or synechiae in the vein or tortuous vein making passage of an endovenous device impossible (unless multiple access points are chosen)

Treatment of incompetent superficial truncal veins in patients with previous deep vein thrombosis requires a careful assessment of the adequacy of the patent segments of the deep venous system. It also requires a risk stratification of postprocedural thrombosis. ELA is appropriate if the deep system is adequate enough to support venous drainage and the superficial venous incompetence is responsible for significant symptoms or skin changes. If the patient has an ongoing risk for thrombosis, ELA may still be appropriate if that risk can be sufficiently decreased with prophylactic anticoagulants. If saphenous reflux is seen with venous ulcers with an adequate deep venous system, ELA of the causative veins is necessary to minimize the risk of a recurrent ulceration.

Treatment of competent enlarged superficial venous segments has no proven medical benefit and should not be performed. In some cases, the enlarged vein may be functioning as a re-entry or collateral pathway for another source of reflux or deep vein obstruction. The use of ELA to close incompetent perforating veins has been described, and studies show a benefit in ulcer healing and recurrence.\textsuperscript{5, 6}
Anesthesia

Tumescent anesthetic, when used in phlebology, describes the use of large volumes of dilute anesthetic solutions that are infiltrated into the perivenous space of the veins to be treated. The rationale behind the use of large volume tumescent anesthesia for ELA include its use as a local anesthetic, its ability to empty the vein to maximize the contact of the thermal device and the vein wall for efficient thermal transfer to the vein wall, and providing a protective heat sink around the treated vein to minimize heating of adjacent structures.

ELA is usually performed with a dilute tumescent anesthetic solution of lidocaine with or without epinephrine in normal saline, often buffered with sodium bicarbonate (a concentration of 0.1% lidocaine is typically used with an average volume of about 5–10 mL/cm of treated vein). This should be delivered with ultrasound guidance into the perivenous space (saphenous sheath) of the vein to be treated. It can be injected either manually or with an infusion pump, such that upon completion of the process the vein is surrounded along its entire treated length with the anesthetic fluid, as demonstrated in the image below.

![Transverse ultrasound image of tumescent anesthetic fluid surrounding centrally located great saphenous vein and laser fiber/sheath.](image)

Although the maximum safe dosage of lidocaine using the tumescent technique for venous procedures is not well studied, 35 mg/kg with epinephrine has been reported as safe in the plastic surgical literature. However, the US Food and Drug Administration (FDA)–reviewed circulars accompanying units of lidocaine state a maximum dose of 5 mg/kg without and 7 mg/kg with epinephrine with each use. Toxicity may occur related to the dose of lidocaine and or epinephrine. Care should be used in patients who are likely to be more sensitive to the dose of these drugs, including elderly persons. When using epinephrine, the use of ECG monitoring may be prudent.

Equipment

Basic equipment and supplies for ELA are listed below.

- Procedure table that can tilt to Trendelenburg and reverse Trendelenburg
- DUS with at least a 7.5 MHz transducer
- Sterile gowns, gloves, masks, drapes, gauze
- Ultrasound gel, sterile ultrasound probe and cord cover
- Antiseptic preparation fluid
- Local anesthetic
- No. 11 scalpel blade, 18-gauge needle, 15° ophthalmic blade, or punch biopsy device
- 18- to 21-gauge needle for percutaneous entry
- 21- to 25-gauge needle for administration of tumescent anesthesia
- Syringes
- Normal saline

• Compression stockings

A foot pedal controlled tumescent anesthetic injection pump can be used to infuse the perisaphenous anesthetic as an alternative to hand injection. Venous access kits that allow the use of a less traumatic 21-gauge needle to insert a 0.018-in guidewire are useful when accessing small veins but do add expense to the procedure. These kits include a 4 or 5F sheath with a dilator tapered to the 0.018-in guidewire. After the catheter and dilator are inserted, the dilator and 0.018-in guidewire can be removed to allow the placement of a standard 0.035-in guidewire. These micropuncture kits are marketed by a variety of vendors.

Additional materials required to perform ELA include the laser generator and sterile laser fiber (see list below) and sheath long enough to cross the abnormal venous segment(s), usually included in a kit along with a guidewire. ELA is usually performed by placing a 4 or 5F sheath into the vein to be treated over a 0.035-in guidewire and then, after inserting a laser fiber into the sheath, withdrawing the sheath to expose the fiber tip. The sheaths are manufactured in multiple lengths and generally the sheath chosen is as long as or longer than the segment(s) to be treated. Sheaths that have a ruler imprinted on them make it easiest to monitor the rate at which they are withdrawn. In very straight veins, a laser fiber can be advanced beyond its sheath to the starting point of ablation. Kits are now available with blunt-tip laser fibers to facilitate this. However, advancement through the sheath is recommended in tortuous veins to avoid passing the fiber through the vein wall.

ELA tools

ELA can be performed using any of the following wavelengths. Generators and laser fiber kits for use are marketed by multiple vendors, as follows:

Endovenous laser wavelengths commercially available include:

- 810 nm (AngioDynamics Queensbury, NY)
- 940 nm (Domier MedTech Americas, Inc, Kennesaw, Ga)
- 980 nm (Biolitec, Inc, East Longmeadow, Mass)
- 1064 nm (Sharplan, Inc., NJ)
- 1320 nm (CoolTouch, Roseville, Calif)
- 1470 nm (Biolitec, Angiodynamics)

Laser ablation has been primarily performed with 810-µm bare-tipped fibers, which are premarked to allow the operator to know when the fiber is tip-to-tip with the end of the sheath and when the laser extends a fixed distance beyond the sheath tip. Although many of the original fibers were bare-tipped, many of the currently used fibers are jacketed with ceramic or metal, which, in theory, may decrease vein wall perforation and increase the effective diameter of the fiber, resulting in a decrease in the power density and changing the fiber from a cutting mode into a coagulation mode.[2] Anecdotally, with similar power settings and pull-back rates, there is less pain and bruising, although the long-term success has not been characterized to see if this results in a trade off in efficacy. Limited data are available that compare the different configurations, but anecdotally it is thought that higher, water-specific wavelengths produce less postprocedure pain with equivalent outcomes.

Positioning

Access to the target vein should be performed with the patient in the supine position. The use of a reverse Trendelenburg position (feet down) in order to increase pressure in the target vein and increase the likelihood of a successful puncture is advisable, especially with small-diameter veins. Once the sheath and laser fiber are inserted...
as described below, the patient is positioned flat and then in the Trendelenburg position after positioning the laser fiber at the desired starting location. The Trendelenburg position helps to empty the vein and improve energy transfer from the fiber to the vein wall. This is particularly important at the upper end of the greater saphenous vein (GSV), where the vein diameter is larger and the vein is less susceptible to spasm.

**Technique**

**ELA procedure** for through the sheath laser fiber kits

1. Perform preprocedural DUS for mapping of the venous segments to be treated. Mark the course of the vein(s) to be treated and important anatomical landmarks associated with the ablation on the skin, including the proposed venous access site(s) and deep vein junctions. The access site is ideally at the inferior end of the incompetent segment or segments of the treated vein. In most cases, the entire incompetent segment(s) can be treated with 1 puncture. If microphlebectomy will be performed along with ELA, the veins to be removed should be marked at this time as well.

2. Prepare the operative tray and equipment. Aside from the thermal ablation device and a venous access kit, only basic supplies such as gauze, a sterilizing solution, sterile barriers, and the tumescent solution, with delivery syringes and needle and an ultrasound probe cover, are needed.

3. Carry out sterile preparation and draping of the leg to be treated. Preprocedural antibiotics are not necessary in almost all circumstances as the procedure is performed steriley and is considered clean.

4. Visualize the access site with DUS. Placing the patient in a reverse Trendelenburg or partly sitting position prior to the venous puncture keeps the vein more distended and may facilitate venous access.

5. Anesthetize the access site. Nick the skin just large enough to facilitate entry of the sheath through the skin.

6. Insert the access needle into the great saphenous vein (GSV) under sonographic guidance. Use of a 21G puncture set, as discussed previously, is preferred particularly when the target vein is < 4 mm in diameter when supine. Cutdown is rarely needed and usually only if percutaneous access fails.

7. Place a 0.035-in guidewire into the vein.

8. Confirm intravenous placement with ultrasonography.

9. Place the introducer sheath over the wire.

10. Position the sheath for ELA to the starting point for ablation. Some physicians typically advance the ELA sheath beyond the starting point and later withdraw it with the laser fiber to the starting spot. The movement of withdrawal helps in to accurately identify the tip and position it at the starting point.

11. Remove the wire and its dilator if one is used with the sheath. Check for venous return by aspirating the syringe attached to the sheath and flush. Recognize that the sheath tip may be against the vein wall and may not aspirate freely. Also realize that when flushing, microbubbles of air introduced into the vein may produce an acoustic shadow that may limit the ability to see venous detail and device positions.

12. Introduce the laser fiber into the sheath so that the fiber reaches the sheath tip. There is generally a mark on the fiber to show this. Then fix the laser fiber and carefully pull back the sheath to expose about 2–3 cm of fiber. Then withdraw the entire sheath-laser fiber to the ablation starting spot.

Fine tune the location of the tip of the laser fiber to just below the superficial epigastric vein, anterior accessory GSV (AAGSV), or other large normal junctional vein for the GSV, and just below the thigh extension junction with the short saphenous vein (SSV) for SSV ablations. Some operators choose to position the laser fiber 1-3 cm below the saphenofemoral junction (SFJ) without consideration of the position of the junctional branches. No data support superiority of any of the above procedures in terms of ablation success, junctional recurrences, or common femoral vein thrombosis post procedure. See the image below.
Varicose Vein Treatment With Endovenous Laser Therapy

Longitudinal (sagittal) duplex ultrasound image of the saphenofemoral junction during the positioning of the tip of a laser fiber during an endovenous laser ablation. The laser tip is in the greater saphenous vein (GSV) just beyond the superficial epigastric vein (SEV) origin and is marked by the arrow. FV = femoral vein.

13. Connect the laser fiber to its generator and confirm that the tip is in the correct general location by viewing the visible light aiming beam that can be delivered into the laser fiber tip and visualized through the skin. This is an additional way to ensure that the tip of the laser is being visualized accurately and that the laser connections were made appropriately. If the light is not seen in the expected location, troubleshoot the position of the laser or the connection to the laser to understand why.

14. Administer tumescent anesthesia with ultrasound guidance after the patient has been placed into the Trendelenburg position to help drain the vein.

15. Place appropriate laser safety goggles on everyone in the procedure room and use other appropriate laser safety measures. Connect the laser fiber to the laser and verify proper laser settings. Setting recommendations vary, but aim to deliver at least 70–80 J/cm length of vein treated: at 14 W this is achieved with a pullback rate of 2 mm/s.

16. Set the laser to continuous mode and select the power to be used. Re-verify placement of the laser tip with ultrasound.

17. Activate the laser and withdraw the fiber and sheath at the speed that is dependent on the amount of energy you wish to deliver at the power setting selected with the laser in continuous mode. Many operators deliver 70-100 J/cm at 14 W in continuous mode at 810 nm throughout the length of the abnormal vein. For the GSV and AAGSV, the author uses more energy for the first 10-12 cm (140 J/cm) and less as the laser tip progresses lower down the leg (100 J/cm to the knee and 70 J/cm below the knee). This is done to ensure closure of the proximal vein segment just below the deep vein junction, where failure occurs most, and to decrease the risk of nerve injuries lower in the leg. For the SSV, the author uses about 112 J/cm for the first 3-4 cm, then 100 J/cm for the next 3-4 cm, and then 70 J/cm for the remaining vein.

18. Stop laser energy delivery at the distal aspect of the vein and place the laser in standby mode.

19. Remove the fiber/sheath from the vein. Be sure the entire fiber is removed to exclude the possibility of a fracture of the device intravascularly.

20. Record the watts, laser on-time, total joules delivered, and length of the segment treated. Calculate the withdrawal rate and joules delivered per cm to ensure you have reached the targets for successful ablation.

Pearls

**Technique considerations**

The amount of thermal energy delivered is correlated to the success of ELA. With laser, energy deposition has been
described as either that deposited per centimeter of vein length (J/cm) or as that deposited to the vein wall using a cylindrical approximation of the inner surface area of the vein (J/cm²), which can be considered a fluence equivalent. Durable vein occlusion was demonstrated in an observational series as more likely when the energy delivered exceeded 80 J/cm with a median observation of 30 weeks. High rates of vein occlusion and ultimate DUS disappearance was noted in a series where the thermal dose in each segment of the GSV was tailored to the diameter in that segment. The ranges of energies used to achieve durable ablation included 50 J/cm for veins ≤4.5 mm and 120 J/cm for veins >10 mm in diameter. No increase in complications was seen with any of the higher energy strategies.

To date, a prospective, randomized evaluation of the relationship of the different variables that can be controlled by the operator on the rate of anatomically successful vein obliteration and complication rates has not been performed. These variables include amount of laser energy deposition (J/cm or J/cm²), the rate of energy deposition (power setting), wavelength, and fiber design. Most combinations of treatments above the 70-80 J/cm seem to result in durable closure and some data support the notion that complications and adverse effects are not increased with energies up to 140 J/cm.

The differences between the current thermal ablation technologies are relatively small. Several retrospective analyses of observational data have demonstrated qualitatively similar occlusion and complication rates with a trend toward quicker treatments and better outcomes with ELA compared with the first generation RFA. In a study comparing Closure Fast (CF) and ELA, equivalent treatment times and anatomical success at 6 months were seen with slightly less immediate postprocedure bruising and postprocedure discomfort noted with CF.

ELA bruising and discomfort have been thought to be less with continuous mode laser deposition than with pulsed mode. Limited data suggest that these side effects may be lessened with the use of a laser fiber with its tip covered with a glass cap and metal sleeve as opposed to a bare fiber. This effectively makes the fiber larger and presumably more coagulating than cutting. The prevention of wall contact produced by the jacket-tipped fibers results in less postprocedure bruising and pain in one study that evaluated 20 patients who were treated with bare-tip fibers and jacket-tip fibers.

Excellent anatomic success of 90-100% occlusion rates has been shown for lasers with wavelengths between 810 and 1470 nm. Recently, the 1470-nm radial laser fiber has been shown to have the lowest amount of postprocedure bruising, pain, parasthesia, induration, and superficial phlebitis due to the water-specific wavelength that is thought to directly act on the vessel wall. Moreover, this study showed equivalent anatomic success of 99.6% closure at 1 year following use of the 1470-nm radial fiber.

Complications

Adverse events and complications

Adverse events following ELA occur, but almost all are minor. Ecchymosis over the treated segment frequently occurs and normally lasts for 7-14 days. About one week after ELA, the treated vein may develop a feeling of tightness similar to that after a strained muscle. This transient discomfort, likely related to inflammation in the treated vein segment, is self-limited and may be ameliorated with the use of nonsteroidal anti-inflammatory drugs (NSAIDs), ambulation, stretching, and graduated compression stockings. Both of these side effects are more commonly described after ELA using existing laser protocols than for RFA, but the differences in severity are very small when studied objectively.

Superficial phlebitis is another uncommon side effect of ELA, being reported after about 5% of treatments as...
mentioned previously. There are no published reports of superficial phlebitis after ELA progressing to deep vein thrombosis and it has been managed in most series with NSAIDs, graduated compression stockings, and ambulation. Anecdotally, superficial phlebitis seems to be more common in larger diameter tributary varicose veins or in varicose veins that have their inflow and outflow ablated by ELA. Concurrent phlebectomy of these veins at the time of ELA has been recommended to decrease the risk of this side effect, but at this point no data substantiate this claim.

More significant adverse events reported following ELA include neurologic injuries, skin burns, and DVT. The overall rate of these complications has been shown to be higher in low-volume centers than high-volume centers. The nerves at highest risk include the saphenous nerve, adjacent to the GSV below the mid-calf perforating vein, and the sural nerve adjacent to the SSV in the mid and lower calf. Both of these nerves have only sensory components. The most common manifestation of a nerve injury is a paresthesia or dysesthesia, most of which is transient. The nerve injuries can occur with the trauma associated with catheter introduction, during the delivery of tumescent anesthesia, or by thermal injury related to heating of the perivenous tissues.

Tumescent anesthesia has been demonstrated to reduce perivenous temperatures with laser and RF ablation. The delivery of the perivenous fluid is felt to be responsible for the low rate of cutaneous and neurologic thermal injuries seen in the series of patients treated using perivenous fluid. Neurologic injuries are seen after truncal vein removal and are related to injury to nerves adjacent to the treated vein. The incidence of these adverse events are related to the degree to which objective testing is performed to identify them. In general, paresthesias caused by ELA are usually temporary with the rate of permanent paresthesias typically reported for GSV and SSV as 0–10%.

The one-week paresthesia rate following RFA was shown to decrease from 15% to 9% after the introduction of tumescent anesthesia. Patients treated with laser ELA performed without tumescent anesthetic infiltrations also demonstrated a high rate of such injuries. Evidence suggests a higher rate of nerve injuries when treating the below knee GSV as compared with the above knee segment and the SSV. Treatment of the below knee GSV or lower part of the SSV may be necessary in many patients to treat to eliminate symptoms or skin disease caused by reflux to the ankle.

A retrospective review demonstrated that below knee laser ablation can be performed with an 8% rate of mild but permanent paresthesias with adequate amounts of tumescent anesthesia. This data also suggests that sparing the treatment of the distal 5–10 cm may have clinical benefit and reduce saphenous nerve injury risk in patients with reflux to the medial malleolus. Skin burns following ELA have been reported. Skin burns are fortunately relatively rare and seem to be avoidable with adequate tumescent anesthesia. The rate of skin burn in 1 series using RFA was 1.7% before and 0.5% after the initiation of the use of tumescent technique during RFA. The early experience had rates as high as 4% that decreased to almost 0% as the use of tumescent anesthesia became a standard of practice.

DVT following ELA is unusual. DVT can occur as an extension of thrombus from the treated truncal vein across the junctional connection into the femoral or popliteal veins. The reported rates of junctional thrombosis following GSV ELA varies widely. This variability may relate to the time of the follow-up examination and the methods used. Most published series using early DUS (around 72 hours or less after ELA) document a proximal extension for the GSV around 1%.

The risk of venous thromboembolism (VTE) is higher in patients with a history of prior DVT or phlebitis, CEAP (clinical, etiological, anatomical and pathological) classification of 3 or greater, and male sex.[14] Endothermal heat-induced thrombosis (EHIT) defines the extent of superficial thrombosis and its extension into the deep venous system as proposed by Kabnick.[14] EHIT 1 represents thrombus up to the SFJ, EHIT 2 represents thrombus extending into the femoral vein occupying less than 50% of luminal diameter, EHIT 3 represents thrombus occupying greater than 50% of femoral vein luminal diameter, and EHIT 4 represents occlusive thrombus in the
femoral vein. EHIT 1 is treated conservatively. If identified, EHIT 2 is usually treated with anticoagulation (full or prophylactic intensity are both used), although some advocate early re-examination and conservative care for more minor forms. EHIT 3 and 4, which are much less common, probably merit full anticoagulation.

Those performing the DUS at a later interval identify a lower rate of EHIT. Possibly, the rates are different for different operators with different protocols or the proximal extension of thrombus may be self-limited and may resolve by 1 month without a clinical event. Pooling data from several sources suggest that the incidence is approximately 0.3% after ELA. This type of DVT is almost universally asymptomatic. The significance of this type of thrombus extension into the femoral vein seems to be different from that found with native GSV thrombosis with extension or when compared with typical femoral vein thrombosis.

The incidence of junctional extension of thrombus after SSV ablation has also been described to be low (0-6%). In one study, the rate of popliteal extension of SSV thrombus at 2-4 days after ELA was related to the anatomy of the SPJ. The incidence at 48-72 hours of follow-up was 0% when no SPJ existed, 3% when a thigh extension exists, but 11% when no thigh extension could be identified just above the SPJ. Heparin was used to treat identified thrombus extensions and all regressed. No published data are available on conservative management of transjuncional thrombus extension at either the SPJ or SFJ. However, given that popliteal or femoral vein obstruction develops in significantly less than 1% of patients, including in those series where DUS is not done until 1 month after ELA, the practice of performing early DUS surveillance and aggressive anticoagulation of such findings is controversial.

Neovascularity at the SFJ after ELA, as a form of recurrence of varicose veins, seems to be rare at 1- to 3-year follow-up. Neovascularization was seen in only 2 of the 1222 limbs followed for up to 5 years in an industry-sponsored registry of patients treated with RFA. Longer follow-up may be necessary to feel confident with this observation. However, neovascularization is common and often an early event following high-ligation and stripping (HL/S). Neovascularization may be less common following endovenous procedures because the junctional tributary flow, which was usually ligated at their confluence with the SFJ, is generally not affected with GSV ELA.

Anecdotal reports of laser fiber fracture or retained venous access sheaths have been made to the device manufacturers and a case report exists describing a retained vascular sheath after laser ablation. Respecting the fragile glass laser fibers and being gentle with its handling should help minimize laser fiber fractures. The possibility of a laser fiber fracture should be considered with the removal of the device in each case. Care to deliver thermal energy only beyond the introducer sheath and away from any other parallel placed sheaths when treating 2 veins during the same procedure is essential to avoid severing segments of these catheters. No specific management recommendations of retained intravenous laser fiber or sheath fragments can be made based on the data. However, anecdotally, retained short segments of the distal end of the laser fiber seem to be well tolerated without incident and efforts to remove them may be more prone to adverse events than managing them conservatively.

A case report of an arteriovenous fistula (AVF) between a small popliteal artery branch near the SPJ and the SSV exists. Anecdotal references have been made of additional AVFs between the proximal GSV and the contiguous superficial external pudendal artery. Although thought to be related to a heat-induced injury caused by the thermal device, an AVF could be caused by a needle injury during tumescent anesthetic administration. Ways to minimize the risk of these AVFs include careful advancement of the intravascular devices, atraumatic delivery of the tumescent anesthetic, the use of copious amounts of tumescent fluid, and avoidance of treating the subfascial portion of the SSV where popliteal artery branches exist adjacent to the SSV.

Follow-up Care and Outcomes

Postoperative Care and Instructions

Postoperative care is designed to improve efficacy and minimize side effects and the risk of complications. There is a diversity of opinion about what is necessary as no evidence supports any specific recommendations. Immediately postoperatively, almost all physicians recommend some form of compression. The most common recommendation is for class II compression stockings (30–40 mm Hg) applied immediately after the procedure and worn for 1–2 weeks. The clinical value of this practice is not substantiated by data. Anecdotally, patients feel better with the use of compression, especially during the second week when the pulled-muscle feeling occurs.

Patients are encouraged to ambulate for at least 30–60 minutes after leaving the procedure room and at least 1–2 hours daily for 1–2 weeks. Hot baths, running, jumping, heavy lifting, and straining are discouraged by many physicians for 1–2 weeks. NSAIDs may be taken on an as-needed basis for discomfort.

Patients are generally seen at 1 month after the procedure to assess the results by clinical examination and DUS. Some physicians recommend a follow-up DUS 24–72 hours after the procedure as surveillance for junctional thrombus extension from the treated vein into the contiguous deep vein. However, as mentioned, the yield of this early examination for identifying extension of thrombus beyond the deep junction extending into the femoral vein for GSV or popliteal vein for SSV ablation is at most 1%. Moreover, treatment of such nonocclusive extensions is controversial and increasingly conservative care is recommended. Most physicians agree that repeat DUS at about 9–12 months after the procedure ultimately determines the anatomical success of the ablation.

Results of ELA

General comments

ELA is safely and effectively performed using local anesthesia in an office setting requiring about 45–90 minutes of room time to be performed. Procedure times are dependent on the number of concurrent treated veins, length of segment(s) treated, and whether ancillary procedures, such as ambulatory phlebectomy, are carried out. Patient satisfaction has been reported to be very high.
The total cost (cost of the procedure plus societal cost) of endovenous procedures is likely equal to or better than that of surgery. This is debatable in a hospital setting, but is almost certainly true if the ELA can be performed in a nonspecialized office setting. These techniques are being rapidly adopted and are now being performed more often than traditional HL/S in the United States.

**Anatomical success rates**

The anatomical outcomes following endovenous treatment include occlusion of the treated segment, early failure (complete or segmental), or late recanalization (complete or segmental). Anatomic success following ELA should result in the treated vein having no lumen and either shrink to a fibrous cord < 2.5 mm in diameter or become sonographically absent 6–12 months after treatment. Anatomical success with ELA of the GSV has been reported between 93–100%. The follow-up for these evaluations varies from 3 months to 4 years.

Table. Published Observational Series of Laser Ablation for Truncal Reflux [15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47](Open Table in a new window)

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<th>Study, Year</th>
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<td>Oh et al, 2003</td>
<td>15</td>
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<td>Min et al, 2003</td>
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<td>98</td>
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<td>Proebstle et al, 2003</td>
<td>39</td>
<td>SSV</td>
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<td>Perkowskiet al, 2004</td>
<td>154</td>
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<td>97</td>
<td>6-18</td>
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Varicose vein after treatment with endovenous laser.
<table>
<thead>
<tr>
<th>Study</th>
<th>Enrollment</th>
<th>Procedure</th>
<th>Follow-up</th>
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<tr>
<td>Sadick et al, 2004</td>
<td>37</td>
<td>SSV</td>
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<td>NR</td>
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<td>Goldman et al, 2004</td>
<td>24</td>
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<td>6(9†)</td>
<td>NR</td>
</tr>
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<td>223</td>
<td>GSV</td>
<td>3</td>
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<td>GSV</td>
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<td>1</td>
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<td>1</td>
<td>NR</td>
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<td>GSV</td>
<td>12</td>
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<tr>
<td>Almeida et al, 2006</td>
<td>483/104</td>
<td>GSV</td>
<td>16‡</td>
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<td>Kim et al, 2006</td>
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<td>GSV</td>
<td>*</td>
<td>36</td>
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<td></td>
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<td>1.5</td>
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<td>30-42</td>
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<td></td>
<td>101</td>
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<td>30-42</td>
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<tr>
<td>Desmyttere et al, 2007</td>
<td>511</td>
<td>GSV</td>
<td>48 (34 limbs at 4 y)</td>
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<td>Darwood et al, 2008</td>
<td>42</td>
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<td>12</td>
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<td>Kalteis et al, 2008</td>
<td>47</td>
<td>GSV</td>
<td>4</td>
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<td>69</td>
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<td>Rasmussen et al, 2013</td>
<td>69</td>
<td>GSV</td>
<td>60</td>
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</tbody>
</table>

NR: Not reported; GSV: Great saphenous vein; SSV: Short saphenous vein.

* Survival determined by Kaplan-Meier analysis.
† EVL SFJ thrombus extension.

‡ Mean measurement.

Fewer data are published following SSV ablation with ELA but the results are qualitatively similar to that found with GSV ablations.

Most ELA recanalizations occur in the first 6 months and all in the first 12 months following ELA. This suggests that recanalization may be related to insufficient thermal energy delivery to the target vein with resultant vein thrombosis and recanalization of the thrombus. Most early recanalizations after GSV ablation can be avoided by using laser energy greater than 80 J/cm and a continuous mode of laser energy application. Late clinical recurrence is extremely unlikely in an occluded vein that has shrunken to a noncompressible cord. Based on this and the surgical data that demonstrate the pathological events that lead to recurrence, which usually take place within 2 years, later clinical recurrences are more likely related to development of incompetence in untreated veins or vein segments (progression of disease in other veins).

To a great extent, late clinical success after ELA is predicated by the natural history of the venous insufficiency in a given patient, the ability of the treating physician to identify refluxing pathways and plan treatment (often described as tactical success) and successfully eliminate all pertinent incompetent pathways (often described as technical success), and the success of the adjunctive procedures used to eradicate any coexistent incompetent tributary veins after ELA.

With ELA, in most cases the first 1-2 cm of the treated vein beyond the SFJ or SPJ remains patent as treatment is begun just below this level. Post-ELA patency of segments less than 5 cm long beyond the junction are the most common form of anatomical failure. Clinically, in spite of this, nearly all of these patients benefit from the procedure. However, the patent stump of GSV is usually connected to a saphenous tributary, which, over time, may reflux and be the source of a clinical recurrence.

Posttreatment patency of greater than 5 cm of treated vein segments are much less common and are more likely to be associated with persistent or recurrent symptoms. Less successful closure of the proximal vein segment may be related to insufficient thermal injury to this portion that is generally of larger caliber and less likely to develop spasm during tumescent anesthetic administration and consequently more difficult to empty. As a result, it is less likely to develop good device and vein wall apposition in this segment, which is thought important for optimal vein wall energy deposition to achieve successful ablation.

Patients with a high body mass index have been shown to have a higher rate of failure with laser. The rationale for this observation is unclear, although it is known that obese patients have higher central venous pressures and a higher frequency of chronic venous disease. ELA success has been demonstrated in a retrospective data review to be independent of vein diameter in many studies. However, a prospective confirmation of this conclusion has not been performed.

**Evaluation of Clinical Outcomes**

Clinical outcomes from varicose vein ablation can be quantified by numerous reporting systems, including the Clinical, Etiologic, Anatomic, Pathophysiologic (CEAP) classification, the revised Venous Clinical Severity Score...
(VCSS), and several patient reported metrics including generic instruments such as the SF-36 and several disease-specific instruments such as the Aberdeen Varicose Vein Questionnaire (AVVQ), Chronic Venous Insufficiency Questionnaire (CIVIQ) 2, Venous Insufficiency Epidemiological and Economic Study (VEINES), and Varicose Veins (VV) Symptoms Questionnaire (VVsymQ). The VVsymQ may be the best patient-reported metric because it has been approved by the FDA for use in device and drug trials.

Several studies have documented significant and durable improvements in validated assessments of quality of life following ELA, which were at least as good as or better than the improvements seen following HL/S in one study. Evaluation of the effectiveness of ELA in CEAP 4-6 patients was performed in a retrospective review of patients 6 weeks after they were treated with RFA and laser; 85% vein occlusion was noted overall, with significant improvements in the VCSS and air plethysmography (APG).

Ulcer healing has been induced after ELA. One report documented an 84% success rate with ulcer healing with a combination of either RFA or laser and microphlebectomy, with 77% of these healing within 2 weeks of the procedure. The Effect of Surgery and Compression on Healing and Recurrence (ESCHAR) study showed that removal of the refluxing superficial veins significantly reduces ulcer recurrence rates at 3 years. Treatment of incompetent perforators likely also play an important role in healing active ulcers and preventing recurrence.

Several small comparison studies have evaluated the outcomes of laser ablation and surgery. In the first to be published, 20 patients with bilateral GSV reflux were treated with conventional HL/S on one leg and HL and laser in the other and then observed for 3 months. The patients were not informed which leg received either therapy, the choice of which technique used was randomized, and all patients were treated with either a spinal or epidural anesthesia. No tumescent anesthetic was used. Early pain was similar for both procedures, although bruising and swelling were worse with surgery. All patients thought the aesthetic improvement was much better in both limbs, but 70% thought the laser limb benefited the most, 20% the surgical limb, and 10% thought they were equal. APG improvements were equivalent in both groups.

A nonrandomized, consecutive treatment comparison of conventional HL/S with general anesthesia and laser ablation of the GSV using tumescent anesthesia has been performed. The authors demonstrated that with the 36-Item Short Form Health survey (SF-36) at 1 and 6 weeks, the patients treated with laser did not suffer the decrease in quality of life seen in the surgical group at the same time. By 12 weeks, both groups had similar improvements in quality of life and in an objective assessment of the severity of their venous disease. The VCSS improvement was significant compared with the pretreatment assessment and similar for both groups of patients.

A randomized comparison of 118 limbs treated with laser and microphlebectomy and 124 with conventional HL/S and microphlebectomy compared the quality of life of the postprocedure period of both procedures. The study demonstrated significantly less postoperative morbidity for the laser procedure using the CIVIQ. In addition, patient satisfaction, analgesia use, and the duration of days before return to work were significantly better for the laser-treated group.

A randomized trial of 68 limbs treated with HL/S and 62 with laser was performed with both groups only being treated with tumescent anesthesia. The preliminary report of this ongoing study evaluated the patients up to 6 months after their procedure using a variety of validated instruments, including a visual analogue scale of pain, VCSS, AVVSS, and SF-36. Initial technical successes were equivalent. In this trial, the early bruising and pain favored laser, but by 3 months both procedures demonstrated significant improvements in all indices compared with pretreatment baselines, but no differences were seen between HL/S and laser. Five-year follow-up data from this study demonstrates no difference in the number of reoperations for recurrent varicose veins as well as improved AVVSS and several domains of the SF-36 in both patients treated with ELA and HL/S.
A randomized trial of 280 patients comparing HL/S and ELA of the GSV confirmed that both treatments resulted in significant reduction in objective severity of disease, lower VCSS scores, lower AVVQ scores, and improved quality of life. ELA also showed decreased postprocedure pain and earlier return to work than surgery.[56]

A randomized trial of 106 patients receiving HL/S versus ELA of the SSV demonstrated similar findings to the GSV, with equal clinical benefits at 1 year, decreased periprocedural morbidity, earlier return to work, and a significant reduction in sensory disturbance.[57]

**Summary**

Since its introduction, ELA has replaced ligation and stripping procedures of the GSV and SSV to eliminate reflux. The procedure has been validated to result in reliable elimination of saphenous vein reflux, is safe, well tolerated, and durable. In addition, it has been shown to produce less periprocedural pain, shortening the recovery to allow for earlier return to work.

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15. Proebstle TM, Gul D, Lehr HA, Kargl A, Knop J. Infrequent early recanalization of greater saphenous vein


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