Varicose Veins: Endovenous Laser Treatment

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Core Messages

- Endovenous laser ablation (EVLA) has been developed as an alternative to surgery of the great saphenous vein and short saphenous vein in an attempt to reduce morbidity and improve recovery time.
- EVLA can be performed in an outpatient special procedure room in a hospital.
- EVLA works by means of thermal destruction of venous tissues. Several wavelengths can be used: 810, 940, 980, 1,064, 1,320, 1,470, and 1,500 nm.
- Heating decreases with tissue depth as absorption and scattering attenuate the incident beam. Consequently, the laser beam must heat the vein wall and not the blood.
- Before EVLA is performed, the vein lumen must be emptied of its blood by using leg elevation (Trendelenburg positioning), manual compression, and infiltration with perisaphenous subcutaneous tumescent saline solution.
- The appropriate linear endovenous energy density (LEED) must be selected as a function of the diameter of treated segment. Veins larger than 9–12 mm in diameter are difficult to treat, even when using higher energy.
- In a general manner, side effects are energy dependent. LEED more than 100 J/cm is very often associated to superficial burns and palpable indurations.

15.1 Introduction

Varicose veins are dilated, tortuous veins of the subcutaneous/superficial venous system. Varicose veins represent a significant clinical problem because they actually represent underlying chronic venous insufficiency with ensuing venous hypertension. This venous hypertension leads to a broad range of clinical manifestations, ranging from symptoms to cutaneous findings like varicose veins, reticular veins, telangiectasias, swelling, skin discoloration, and ulcerations. Once venous hypertension is present, the venous dysfunction continues to worsen through a vicious cycle. Over time, with more local dilatation, other adjacent valves sequentially fail, and after a series of valves has failed, the entire superficial venous system is incompetent. This lower-extremity venous insufficiency is a common medical condition afflicting 25% of women and 15% of men in the United States and Europe. The drainage of the superficial system takes several pathways. The most important is the great saphenous vein (GSV). In patients with varicose disease, the GSV is

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incompetent in 70–80%. The GSV reflux is due to saphenofemoral junction (SFJ) incompetence. The small saphenous vein (SSV) is affected in about 10% of patients with varicose disease. Sapheno-popliteal junction (SPJ) incompetence and SSV reflux, although less common than GSV reflux, may result in symptoms of equal severity. Isolated anterior saphenous vein reflux occurs in approximately 10% of patients [2, 20, 51]. Another cause of reflux is incompetent perforating veins. All four major causes of reflux can be treated with endovenous laser ablation (EVLA). In about 10% of the patients, varicose veins appear without affecting one of those four pathways.

Treatment of GSV reflux has traditionally been surgical. However, recurrence in 30–60% of cases has been reported [2]. It is also associated with significant perioperative morbidity. Less invasive surgical treatments, including high ligation of the GSV at the SFJ, have been attempted in the hope that gravitational reflux would be controlled while the vein is preserved for possible use as a bypass graft. Unfortunately, ligation of the GSV alone usually results in recurrent varicose veins. Even when high ligation has been combined with phlebectomy of varicose tributaries or retrograde sclerotherapy, recurrence has been the rule. Therefore, when it is determined that GSV reflux is the principal underlying problem, treatment should involve eliminating this source of reflux with ablation of any associated incompetent venous segments [20]. Though inadequate surgery of the SFJ and progression of the disease are mechanisms that explain some cases of recurrence, another important mechanism is neovascularization around the junction after venous surgery. Neovascularization has been reported to be the principal cause of recurrence with clear histologic evidence [51]. Surgery for the incompetent SSV is even more challenging, with more complications and higher recurrence rates, than for the GSV. The potential for damage to the sural nerve with resulting neurological deficit has deterred many vascular surgeons from stripping the SSV routinely [28, 41]. Most commonly, the SSV is ligated only at the SPJ. Recurrence rates of SSV after surgery are about 30–50% at 5 years [2, 26, 47].

Within the last few years, minimally invasive techniques such as radiofrequency ablation and chemical ablation have been developed as alternatives to surgery in an attempt to reduce morbidity and improve recovery time. EVLA is one of the most promising of these new techniques. EVLA is becoming an established treatment option for GSV and SSV incompetence, with success rates comparable to those of conventional surgery [7, 20, 25].

15.2 EVLA Mechanism of Action

EVLA works by means of thermal destruction of venous tissues. Laser energy is delivered to the desired incompetent segment inside the vein through a bare laser fiber that has been passed through a sheath to the desired location.

Several wavelengths have been proposed: 810, 940, 980, 1,064, and 1,320 nm [4, 14, 19, 29, 34] with 810, 940, and 980 being the most commonly used. More recently, use of a 1,470- to 1,500-nm diode laser has been proposed. Wavelengths of 1,470–1,500 nm are preferentially absorbed by water [43, 48].

When using laser light, heat is generated within the zone of optical penetration by direct absorption of laser energy. Absorption is the primary event that allows a laser or other light source to cause a potentially therapeutic (or damaging) effect on a tissue. Without absorption, there is no energy transfer to the tissue and the tissue is left unaffected by the light. Scattering of light occurs in all biological tissues: blood, vessel walls, and perivenous tissue. Due to fluctuations in the refractive index of these media, the propagation of light into the tissue is modified and the scattering affects "where" the absorption will occur, usually reducing the penetration of light into the tissue.

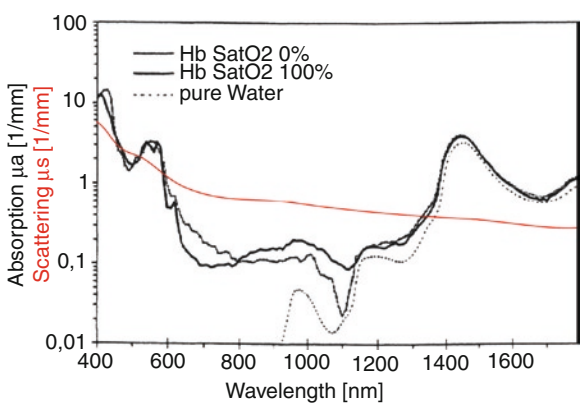

Fig. 15.1 Absorption and scattering (*red*) coefficients of blood relative to wavelength (from Vuylsteke et al. [48])

Table 15.1 Absorption, reduced scattering and extinction coefficients of blood, vessel wall, and perivenous tissue relative to wavelength [48]

	(mm^{-1})	Wavelength				
		810	940	980	1,320	1,500
Blood	μ_a	0.16	0.25	0.28	0.38	3.0
	μ'_s	0.73	0.64	0.6	0.54	0.52
	μ_{eff}	0.65	0.82	0.86	1.02	5.63
Vessel wall	μ_a	0.2	0.12	0.1	0.3	2.4
	μ'_s	2.4	2.13	2.0	1.8	1.7
	μ_{eff}	1.25	0.9	0.79	1.37	5.43
Perivenous tissue	μ_a	0.017	0.027	0.030	0.045	0.35
	μ'_s	1.2	1.1	1.0	0.9	0.84
	μ_{eff}	0.25	0.3	0.3	0.36	1.12

This table clearly shows that the optical extinction is much higher at 1,470–1,500 nm (5–9 times higher) compared to 810, 940, 980, and 1,320 nm. Interestingly, for these wavelengths, the optical extinction is similar for blood and vessel wall

Heating decreases with tissue depth as absorption and scattering attenuate the incident beam. Based on the absorption and effective scattering coefficients of the biological tissue, the optical extinction (μ_{eff}) can be determined [21] (Fig. 15.1, Table 15.1).

15.3 Role of Blood

The exact mechanism of EVLA remains the subject of controversy. Many studies are based on the assumption that during EVLA the vein is filled with blood. Based on our clinical experience with more than 1,000 patients, the presence of blood inside the vein has several consequences [6, 7, 23]:

- Blood around the fiber tip reduces the transmission of light to the biological target of EVLA: the venous wall [49]. Because thermal damage of the inner vein wall (tunica intima) is required to achieve the tissue alterations necessary for permanent vein occlusion, the presence of blood greatly hinders the effect of the laser to the vessel wall.
- If the laser light energy is entirely absorbed by blood, the initial success rate will be mainly due to a thrombotic effect; however, thrombus dissolution will lead to recanalization, as clearly demonstrated by Proebstle et al. [36]
- The presence of blood can generate steam bubbles. The formation of these steam bubbles has been confirmed by Proebstle et al. [33], who have observed that they were generated in hemolytic blood by 810-, 940-, and 980-nm diode lasers, whereas no bubbles were produced in normal saline or plasma. However, this mechanism is now considered of secondary importance for EVLA efficacy [46].
- Last, but not least, the presence of blood induces carbonization at the fiber tip and often melting of the glass fiber tip. This phenomenon implies fiber tip temperatures in excess of 1,200°C. This melting point of the glass fiber tip has been observed by Fan and Anderson [12]. Figure 15.2 gives a good example of the fiber tip destruction obtained when laser irradiation is performed inside a vein filled with blood. The partial destruction of the tip compromises beam homogeneity, which leads to unpredictable energy distribution inside the vein. Furthermore, the carbon layer rapidly forming at the tip absorbs most of the light energy and converts it into heat, radically altering the laser/tissue interaction process.

The variability in the amount of blood within the vein leads to inconstant results. In our experience, before performing EVLA the vein lumen is emptied out of its blood by using leg elevation (Trendelenburg positioning), manual compression, and infiltration with a perisaphenous subcutaneous tumescent saline solution. This solution of local anesthesia serves three purposes. First, the vein itself and the surrounding tissues are anesthetized. Secondly, the fluid around the vein helps to protect the surrounding tissues from any collateral injury from the heat of the laser. This

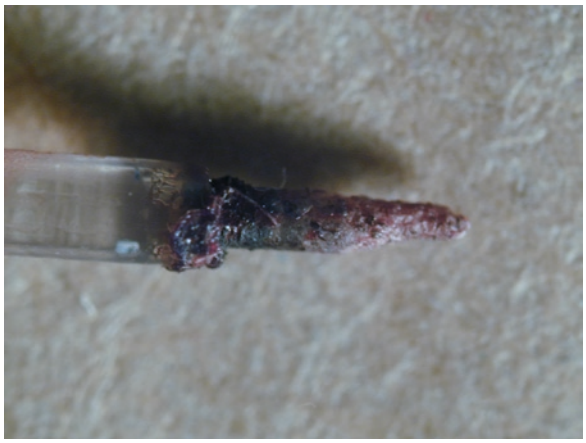

Fig. 15.2 Tip of the fiber inserted in a vein filled with blood; there was no Trendelenburg positioning and no manual compression, only tumescent saline solution infiltration (vein length 45 cm, 980 nm, 15 W, CW)

surrounding fluid acts as a "heat sink" to protect these tissues. Thirdly, the fluid exerts compression around the vein and induces spasm of the vein (Figs. 15.3 and 15.4).

Thanks to these three maneuvers, no or little blood remains in the vein. Figure 15.2 shows the example on a fiber tip after the treatment of a GSV (vein length: 45 cm, 980 nm, 15 W, continuous wave (CW)). This tip is intact with no carbonization (Fig. 15.5).

15.4 Procedure

A clinical history is taken, and physical examination, including duplex ultrasound (US) imaging evaluation of the superficial venous system, is performed in the limbs of patients with varices suspected of arising from the GSV or the SSV. Patients with impalpable pedal pulses; cardiovascular disease; inability to ambulate; deep vein thrombosis; general poor health; and patients who are pregnant, nursing, or planning to become pregnant are usually not treated. Patients with extremely tortuous GSVs or SSVs that would not allow endovenous catheterization and passage of the laser fiber as identified on pretreatment venous duplex US mapping are excluded.

Duplex US is performed in the upright position to map incompetent sources of venous reflux and then to mark the skin overlying the incompetent portion of the GSV starting at the SFJ (Fig. 15.6). GSV diameter is measured, with the patient in an upright position, in different locations (1.5 cm below the SFJ, crural segment, condylar segment, and sural segment) to enable selection of the appropriate linear endovenous energy density (LEED) for each segment. For the SSV, the incompetent portion is marked starting at the SPJ, following the same procedure.

Usually, in an outpatient special procedure room in a hospital, the target extremity is sterilized, prepped,

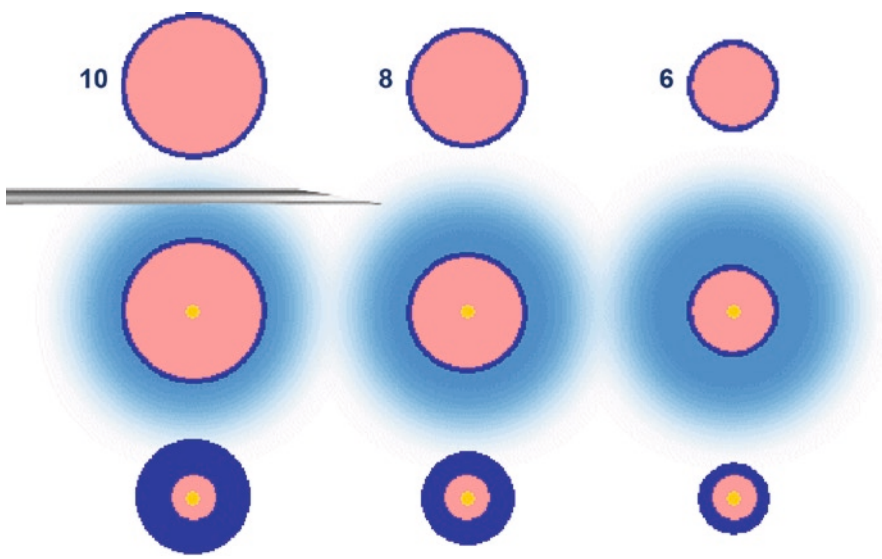

Fig. 15.3 Principle of tumescent anesthesia. This solution of local anesthesia serves three purposes. First, the vein itself and the surrounding tissues are anesthetized. Secondly, the fluid around the vein helps to protect the surrounding tissues from any collateral injury from the heat of the laser. Thirdly, the fluid exerts compression around the vein. Consequently, the diameter is considerably reduced and no or little blood remains in the vein

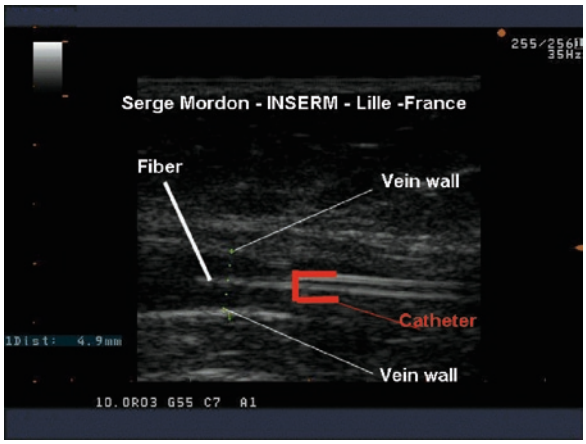

Fig. 15.4 Ultrasound image showing the catheter and the laser fiber inserted in the Saphenous vein

Fig. 15.5 Tip of the fiber inserted in to a vein with almost no blood. In this case, the patient was maintained in Trendelenburg positioning and manual compression was performed (vein length 45 cm, 980 nm, 15 W, CW-tumescent saline solution infiltration)

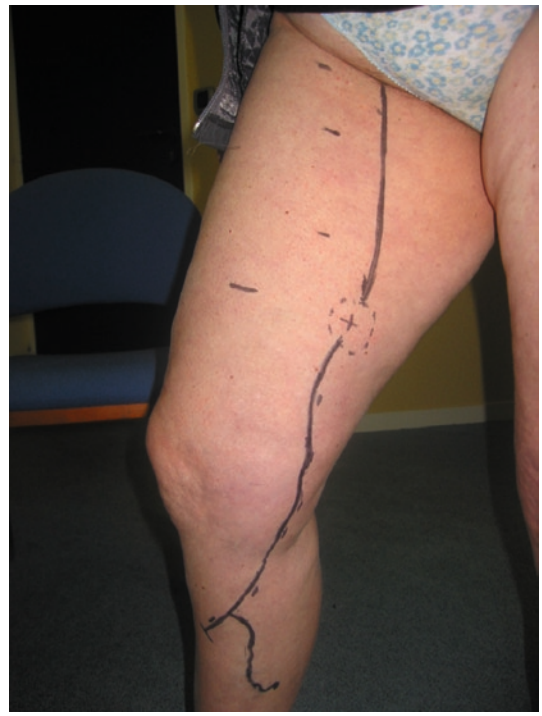

Fig. 15.6 Duplex ultrasound is performed in the upright position to map incompetent sources of venous reflux and then to mark the skin overlying the incompetent portion of the great saphenous vein starting at the saphenofemoral junction

and draped. Under US guidance through a sterile US probe cover, the GSV is visualized at the level of the knee. The vein is percutaneously punctured with a 21-gauge needle under US guidance. A 5-F microintroducer guidewire is threaded through the needle followed by the introducer. A 0.035-in. guidewire is passed under ultrasound guidance up to the SFJ; a 5-F introducer is placed over the guidewire. A 600-μm optical fiber is passed through the introducer to the SFJ. Its position is verified by US and by visualization of the aiming beam through the skin. Duplex control is used to guide injection of 7–8 mL aliquots of the tumescent solution (Fig. 15.7). Several solutions can be used: (a) 10 mL lidocaine 1% withepinephrine and 10 mL lidocaine 1% without epinephrine and an additional 60 mL physiologic serum, (b) 10 mL 1% xylocaine with epinephrine diluted in 200 mL of saline, mainly to not exceed the safe limits of local anesthesia, and (c) a cocktail of 500 mL bicarbonate 1.4% with 1 ampule (20 mL) of xylocaine at 1%. HCO_3 diminishes the burning sensation from the injection of the local anesthesia. It reduces the amount of xylocaine necessary to obtain good anesthesia and accelerates the anesthetic effect [28, 41].

The injections are performed into the fascial space surrounding the vein at intervals down its length. For the SSV, the procedure is similar except that the SSV is cannulated in the mid to lower calf using a 21-gauge needle and that the fiber is passed through the introducer to the SPJ.

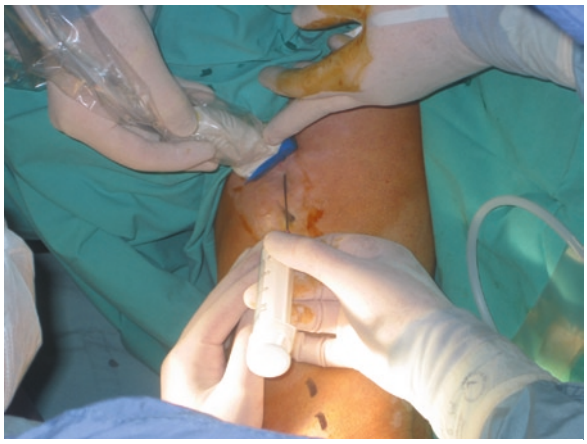

Fig. 15.7 Duplex control is used to guide injection of 7- to 8-mL aliquots of the following solution: 10 mL lidocaine 1% with epinephrine and 10 mL lidocaine 1% without epinephrine and additional 60 mL physiologic serum

To reduce the amount of blood inside the vein, patients are in a 15–20° head-down position (Trendelenburg position) (Fig. 15.8) [6].

Whatever the wavelength is (810, 940, 980, 1,320 nm), power is usually set between 10 and 15 W. The energy is administered endovenously, either in a pulsed fashion (pulse duration of 1–3 s with fiber pullback in 3- to 5-mm increments every 2 s) or continuously with a constant pullback of the laser fiber (pullback velocity ranging from 1 to 3 mm/s) (Figs. 15.9 and 15.10). With these parameters, the average LEED, which is commonly used to report the dose administered to the vein, ranges from 20 to 140 J/cm [24, 36]. Interestingly, even when using 1,450–1,500 nm, the power is set at 15 W and LEED applied is around 100 J/cm [30]. For GSV diameters between 2 and 4.5 mm, the LEED applied is 50 J/cm. The LEED is 70 J/cm for 4.5–7 mm, 90 J/cm for 7–10 mm, and up to 120 J/cm for larger diameters. Consequently, the pulse duration is adjusted for each individual GSV segment from 1.2 s (2 mm) up to 6 s (>10 mm). The last shot is systematically controlled by duplex US to avoid any skin burn and delayed healing. Because tumescent anesthesia is always used, patients feel no pain during EVLA. At the end of the surgical procedure, venous compression is applied for 24 h by irremovable compression bandage (Fig. 15.11). In addition, the patients are asked to wear full-thigh class 2 or 3 compression stockings only during the day for 3 weeks. Patients are instructed to walk immediately after the procedure and to continue their normal daily activities with vigorous workouts. Patients generally report discomfort 5–8 days after EVLA, which is related to the inflammation resulting from successful endovenous ablation (i.e., wall thickening) [42]. It is not related to the presence or degree of ecchymosis, nor is it the result of laser damage to perivenous tissue. If the pain is too intense, nonsteroidal anti-inflammatory drugs can be prescribed.

Fig. 15.8 To reduce the amount of blood inside the vein, patients are placed in a 15–20° head-down position (Trendelenburg position)

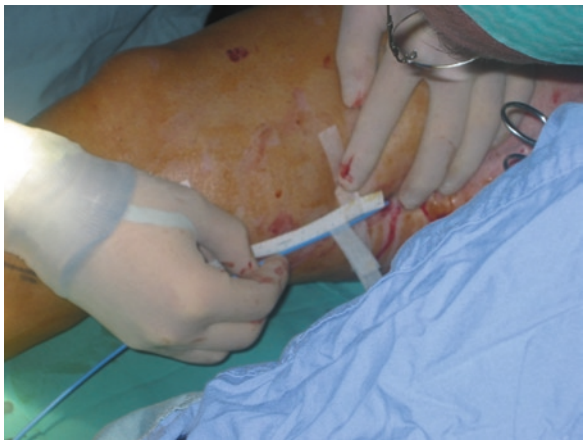

Fig. 15.9 During laser irradiation, the withdrawal of the laser fiber is controlled to apply a constant linear endovenous energy density (in this case, a metric ruler)

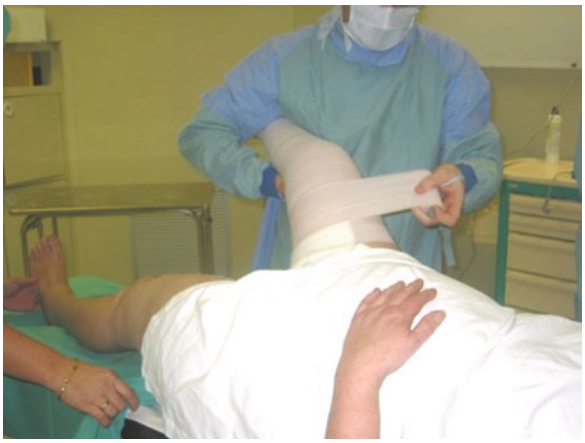

Fig. 15.11 At the end of the surgical procedure, venous compression was applied for 24 h by irremovable compression bandage

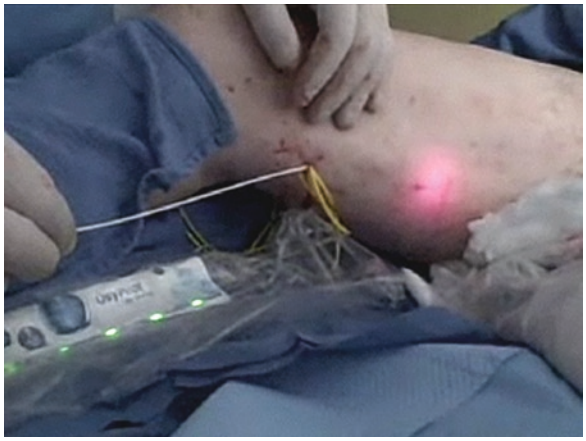

Fig. 15.10 During laser irradiation, pullback of the laser fiber is controlled to apply a constant linear endovenous energy density (LEED) (in this case, the LEED running lights of the Osypilot guide the physician when retracting the fiber from the vein). This controlled fiber withdrawal ensures a precise and consistent delivery of energy throughout the procedure, resulting in maximized safety and results

15.5 Great Saphenous Vein

Valvular incompetence of the GSV is the most common contributor to primary varicose veins. EVLA of the GSV has been widely accepted, and numerous studies already have been published. The largest studies now report data on more than 2,500 patients with a 7-year follow-up. In 2003, [20] have published results of 499 GSVs in 423 subjects with varicose veins treated during a 3-year period with an 810-nm diode laser. Successful occlusion of the GSV, defined as absence of flow on color Doppler imaging, was noted in 490 of 499 GSVs (98.2%) after initial treatment. One hundred thirteen of 121 limbs (93.4%) followed for 2 years have remained closed, with the treated portions of the GSVs not visible on duplex imaging. Forty subjects have been followed for 3 years and no new recurrences were seen at 2 or 3 years that were not present at 1-year follow-up [20]. In 2005, Duran [10] presented a study including 517 GSV in 426 patients with a 24-month follow-up. Among 112 GSVs followed at least 24 months, 98% remained closed or reabsorbed. In 2006, the Italian Endovenous-laser Working Group reported a cooperative multicenter clinical study of 1,050 patients (1,076 limbs) during a 6-year period but with only a 3-year follow-up for all the centers using duplex scanning. The total occlusion rate has been 97% [1]. At 3-year follow-up, Desmyttere et al. [7] obtained an occlusion rate of GSVs of 99.3%. Desmyttere et al. [7] also noted a complete disappearance of the GSV or minimal residual fibrous cord. Finally, in 2009 Ravi et al. [39] reported a 98% occlusion rate in 2,460 GSVs during a 7-year period.

Recanalizations are usually always observed when the SFJ diameter is greater than 1.1 cm in diameter or if the GSV truncular diameter is greater than 0.8 cm [7]. This observation is in agreement with mathematical modeling demonstrating that higher energy should be necessary to treat larger GSV diameters [21, 22]. Several authors have proposed the use of higher LEED to

improve the closure rate. Proebstle et al. [36] have observed that nonocclusion and early reopening of the GSV is energy dependent. Timperman et al. [45] compared two groups of patients: one treated with an average energy delivered of 63.4 J/cm (range 20.5–137.8 J/cm) and a second group treated with 46.6 J/cm (range 25.7–78 J/cm). They showed that failures were mostly associated with the lower LEED. However, treatment failures were also identified in patients who received doses of 80 J/cm or more. Energy delivery for the failures was 120, 80, 110, 98, and 80 J/cm (mean 98 J/cm; SD 18 J/cm), respectively [45]. That failures were always observed when SFJ diameter was greater than 1.1 cm or the GSV truncular diameter was greater than 0.8 cm, where the content of blood is very important even in the Trendelenburg position, confirms that laser irradiation was not sufficient to heat the vessel wall. One can hypothesize that blood remaining inside the lumen could absorb the laser light energy, consequently limiting the light transmitted to the vessel wall.

When performed properly, no dyschromia, superficial burns, thrombophlebitis, or palpable indurations are reported after EVLA. The main side effect is ecchymosis with a rate usually around 50–60%. For example, Sadick and Wasser [40] reported an ecchymosis rate of 61.7%, comparable to the rate obtained by Desmyttere et al. [7]. Proebstle et al. [37] obtained ecchymosis rates of 73.2% (940 nm, 15 W, 1 s, pulsed); 78.2% (940 nm, 15 W, CW); and 81.2% (940 nm, 20 W, CW) [37](Fig. 15.13).

In a general manner, side effects are energy dependent. LEED more than 100 J/cm is very often associated with superficial burns and palpable indurations. For example, vascular perforation with subsequent perivascular bleeding was occasionally (<10%) seen in cases treated with 40–80 J/cm and in all cases treated with 110–200 J/cm [5]. Unintentional vein wall contact and perforation cannot be avoided with any certainty when using a bare-tip fiber [17].

Pain could also be an issue. However, the difficulty with studies that evaluate pain is the significant variation in pain tolerance between patients. What may seem like soreness to one patient might be considered severe pain to another. Even objective measures such as carefully recording usage of pain medication can vary because patients have different pain tolerances. For example, Gibson et al. [13] reported pain in 97% of treated patients. In the series reported by Proebstle [37], the percentage of patients complaining of pain was 72%. In this case, pain was treated with analgesics

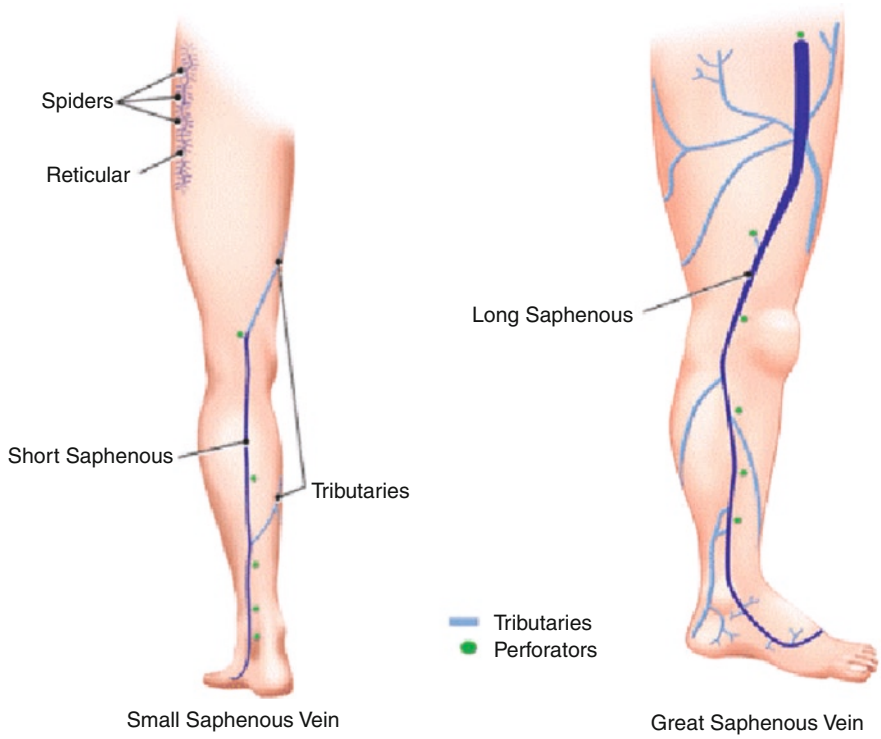

Fig. 15.12 Small saphenous vein and great saphenous vein

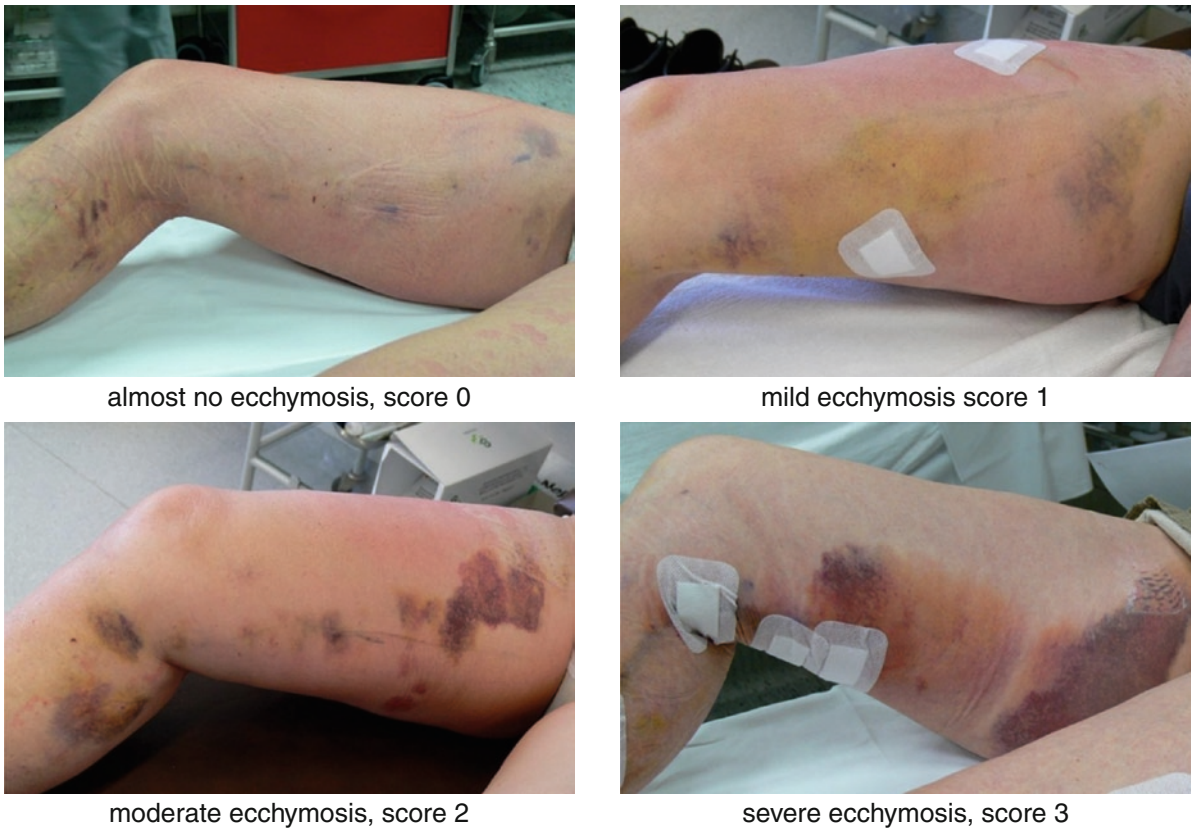

Fig. 15.13 Visual grading used to quantify ecchymosis (from Vuylsteke et al. [48])

twice daily. The median duration of pain and the demand for analgesics lasted usually 1 week, with a maximum duration of 2 weeks [37]. Transitory paresthesia was observed in 7% of treated legs with a median duration of 2 weeks. Huang et al. [16] noted paresthesia in 7.2% of patients. In another study, Proebstle et al. [35] reported an 11% incidence of paresthesia for 3–8 weeks after treatment despite postoperative graduated compression for 8 days.

15.6 Small Saphenous Vein

Surgery for short saphenous varicose veins is more challenging, with more complications and higher recurrence rates than for GSVs. If EVLA of the GSV has been now widely accepted as a treatment for primary varicose veins, EVLA is less often used in the treatment of SSV reflux. The reluctance of practitioners to use EVLT for the treatment of SSV incompetence may be related to concerns about the proximity of the sural nerve to the vein as well as concerns about popliteal thrombosis. However, as demonstrated by previous studies, adequate tumescence of the SSV, which theoretically separates the nerve from the vein, can avoid sural nerve injury [13].

As already proposed by [32] EVLA was started from 1 to 1.5 cm distal to the SPJ to avoid leaving a long residual SSV stump. Therefore, for almost all patients, EVLA was conducted proximal to the site where the Giacomini vein is drained. Similar to GSV, the role of blood during the EVLA should be considered because this may reduce the amount of light transmitted to the vein wall. It is usually recommended that the presence of blood be reduced by emptying the vein lumen using leg elevation (Trendelenburg positioning), infiltration with perisaphenous subcutaneous tumescent saline solution, and manual compression. However, larger veins are often only partially compressed by

these measures, and leg elevation may not be enough to empty the vein. Using higher energy has been proposed to avoid the creation of a thrombus, which can recanalize and cause treatment failure [36, 45]. However, larger veins fold usually, and the fiber-tip is found eccentric intraluminal. In such a situation it is difficult to heat the vein wall sufficiently at the opposite side. Consequently, using higher energy can result in perforation and possible perivenous tissue destruction.

The correct tumescent anesthetic technique is essential to ensure that this procedure is safe and painless. A surrounding fascial envelope containing the tumescent solution provides a margin of safety so heat damage to surrounding structures does not occur [3].

LEED applied during treatment was the main determinant of success because thermal damage of the inner vein wall (tunica intima) is required to achieve the tissue destruction necessary to lead the vein to permanent occlusion. Most clinical studies have been performed with equivalent LEED. When using 980 nm, LEED reported by Park et al. [32] varied between 62 and 77 J/cm. Similarly in a study performed by another team (Park and Hwang [31]), LEED was adjusted to between 50 and 60 J/cm. Theivacumar et al. [44] delivered a LEED of 66.3 J/cm (range 54.2–71.6 J/cm). In a recent study, Desmyttere et al. [8] have adjusted the LEED to the SSV diameter: for SSV diameters between 2 and 4.5 mm, the LEED applied was 50 J/cm. The LEED was 70 J/cm for 4.5–7 mm and 90 J/cm for 7–10 mm [8].

The length of vein treated in this last study (18.2 SD 8.3 cm) was similar to that treated by Nwaejike et al. [27] (18 cm; range 5–33 cm) and Theivacumar et al. [44] (17 cm; range 12–20 cm). The mean total energy (1,200 J) was comparable to mean energy reported by Nwaejike: 955 J (range 135–2,800 J). The mean SSV diameter (5.2, SD 1.5 mm) was also comparable to the average diameter of the SSV in the Elias and Khilnani's [11] series of 50 limbs, which was 5.8 mm.

The clinical outcome of EVLA in the SSV has been reported in few articles. In Park et al.'s [31] series, 4 of 95 SSVs recanalized with the recurrence of reflux at 1-month follow-up. Continued closure of the SSV was seen in 89 of 93 limbs (96%) at the 1-month follow-up, in 87 limbs at the 3-month follow-up, in 82 limbs at the 6-month follow-up, in 77 limbs at the 1-year follow-up, in 71 limbs at the 2-year follow-up, and in 55 limbs (100%) at the 3-year follow-up [31]. In [8] study only three recurrences occurred in veins with a diameter greater than 9 mm. Park et al. [32] also observed recanalization of large diameter SSVs, in most cases greater than 9 mm. Because, the energy applied during treatment is the main determinant of success; it seems that LEED was too low in those three cases. This observation is in agreement with Timperman et al.'s [45] clinical study: greater energy delivery improves treatment success of endovenous laser treatment.

Similarly, the incidence of ecchymoses, pain, and paraesthesia was similar to previous studies, and major complications were not reported. In Desmyttere et al.'s [8] study, all paraesthesia was temporary. In Park et al.'s [31] study, only one patient complained of paraesthesia at 6-month follow-up, with complete resolution at 1-year follow up. The ecchymosis rate is also similar to that observed in GSV, usually around 60%.

15.7 New Developments

As explained in above, most complications (ecchymosis, postoperative pain, paresthesias) are mostly due to vein perforations. Two main factors contribute to these complications: (1) an inadequate LEED, which plays a major role, and (2) an unintentional vein wall contact and perforation, which cannot be avoided with any certainty when using a bare-tip fiber [17].

15.7.1 LEED Standardization

A standardized withdrawal of the fiber is required to deliver a reproducible LEED along the vein. For example, Osyris Medical (Villeneuve d'Ascq, France) has developed a system that helps the operator to achieve a consistent energy delivery during EVLA procedures. The running lights of the Osypilot guide the physician when retracting the fiber from the vein. This controlled fiber withdrawal ensures a precise and consistent delivery of energy throughout the procedure (Figs. 15.14 and 15.15).

Similarly, the motorized pullback of the fiber can secure the exact emission of laser energy during the procedure that could contribute to decrease the rates of perforation, posttreatment bruising, and pain [15].

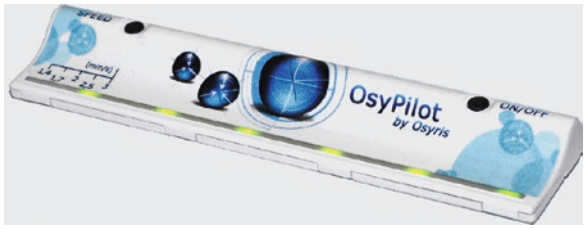

Fig. 15.14 Manual withdrawal can be assisted predetermined speed of the running light-emitting diodes of the Osypilot

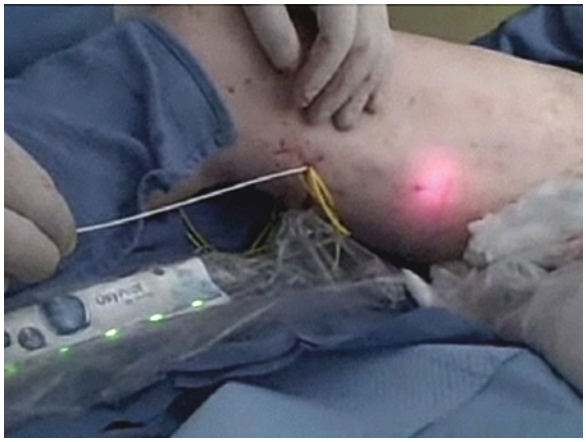

Fig. 15.15 Manual withdrawal can be assisted predetermined speed of the running light-emitting diodes of the Osypilot

Figure 15.16 shows the CoolTouch Corp.'s CTEVTM (Auburn, Calif., USA).

15.7.2 Centering the Bare Fiber

As illustrated in Figs. 15.17 and 15.18, the rigid bare fiber can hit the vein wall during withdrawal and causes ulcerations and perforations of the vein wall.

Recently, two devices have been developed to avoid direct contact of the bare fiber with the vein wall. A possible solution to eliminate vein perforations from laser-tip wall contact is the jacket-tip fiber (NeverTouch, AngioDynamics, Inc., Queensbury, New York, USA) (Fig. 15.19). This type of fiber features a "jacket" at the distal tip of the fiber that covers the energy-emanating portion of the fiber. The jacket prevents the flat emitting face of the fiber from coming into contact with the vessel wall (Fig. 15.19).

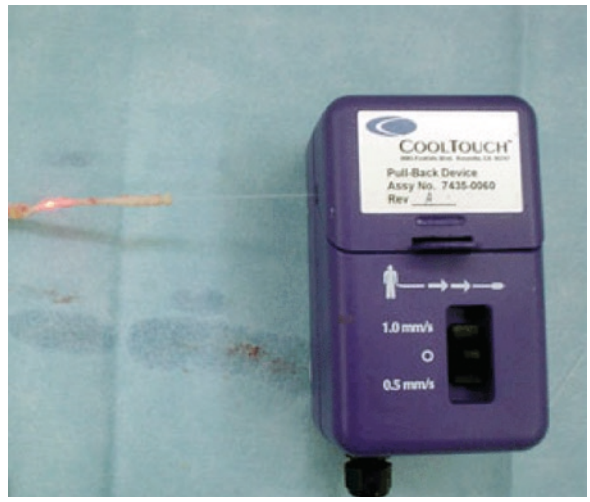

Fig. 15.16 An automated fiber pullback device can withdraw the laser fiber at a rate of 1 or 0.5 mm/s (from Hirokawa et al. [15])

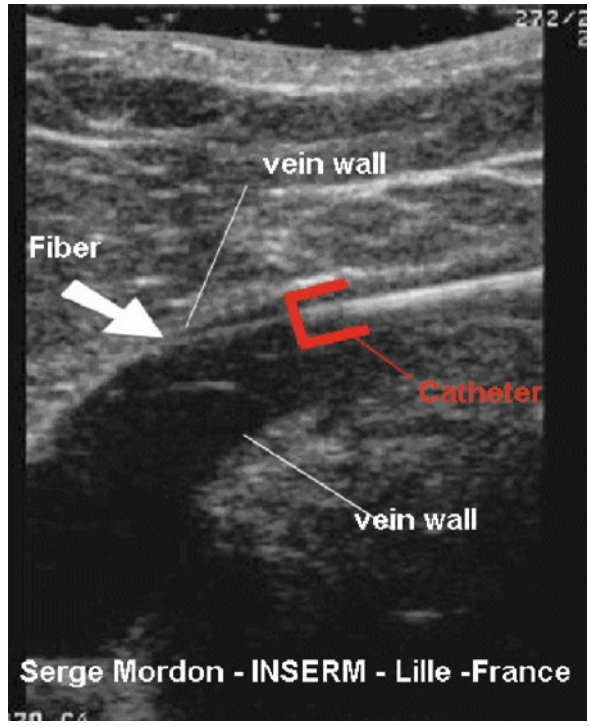

Fig. 15.17 Ultrasound image showing the fiber in contact with the vein wall

A second solution was developed by Vuylsteke et al. [48]. It consists of a tulip-shaped catheter fixed to the fiber to avoid direct contact between the fiber

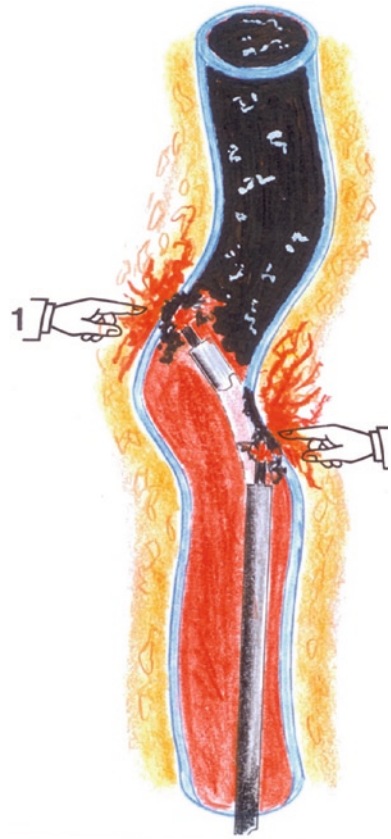

Fig. 15.18 In tortuous veins, the rigid bare fiber hits the vein wall during withdrawal and causes ulcerations and perforations of the vein wall

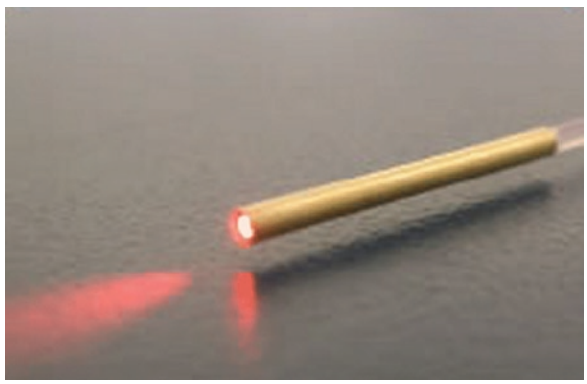

Fig. 15.19 Jacket-tip laser fiber (NeverTouch) developed by AngioDynamics, Inc. from Kabnick and Caruso [17]

tip and the vein wall. This catheter is made of Stainless Steel, a shape-memory and super-elastic material [48].

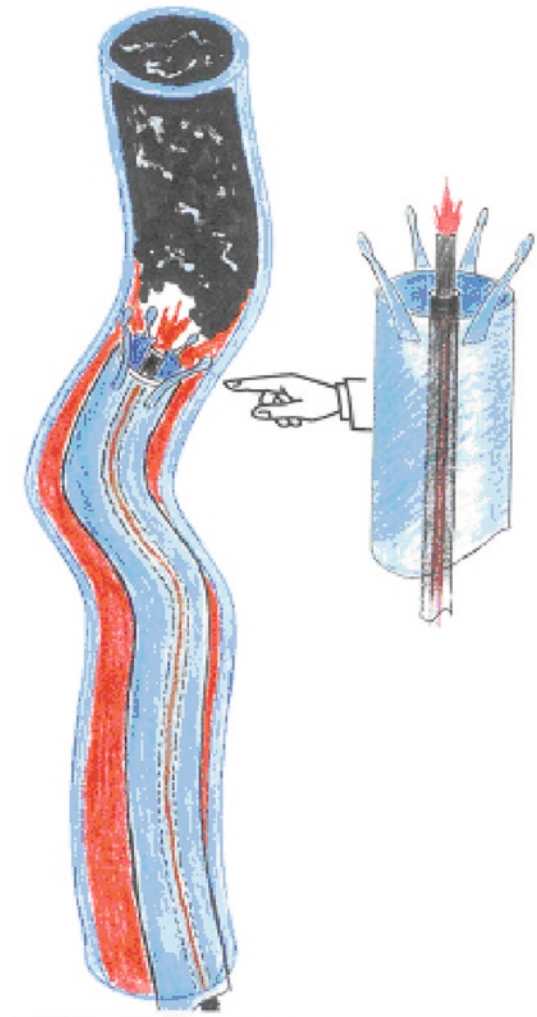

Fig. 15.20 A "Tulip" catheter can be used to center the fiber inside the vein [47]

In an experimental study in goats, Vuylsteke et al. [50] demonstrated that the use of this device avoided the usual ulcerations and perforations of the vein wall. They also observed a more even vein wall destruction with necrosis of a higher percentage of the circumferential vein wall (Figs. 15.20 and 15.21).

15.7.3 Radial Emission

A homogenous, circumferential (360°) energy emission has been proposed recently to avoid the direct

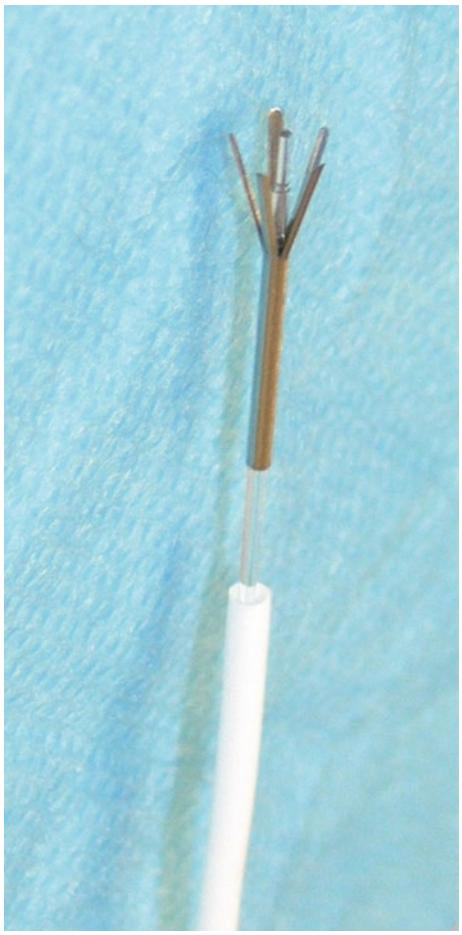

Fig. 15.21 "Tulip" catheter developed by Vuylsteke et al. [47]

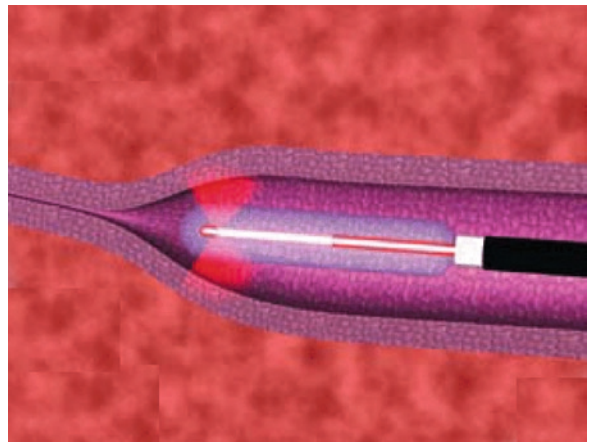

Fig. 15.22 The Elves radial fiber developed by Biolitec

contact of the bare fiber tip (Elves Radial, Biolitec AG, Germany). With this system, the light is directed toward the vessel wall that is the biological target during the EVLA [43]. Long-term follow-up is required to evaluate if the advantages are able to compensate for the higher price of this system compared to the conventional bare fiber (Fig. 15.22).

In conclusion, these new systems could potentially reduce the risk of vein perforations. However, they need to be carefully evaluated.

15.7.4 New Wavelengths

Recently, the 1,470- to 1,500-nm diode laser has been proposed because it is preferentially absorbed by water [43, 48]. However, these wavelengths need to be evaluated carefully. In 2009, there was still a controversy about the power required for treatment. For Maurins and coworkers [18], a power of 15 was required with 1,470 nm, and LEED varying from 90 to 120 J/cm was necessary to achieve occlusion of the vein. However, with such a high LEED, the rate of paresthesia is very high: 9.5% after 6 months and 7.6% after 1 year [18, 30]. For Vuylstke et al. [48] the LEED was reduced to 60 J/cm. For Soracco et al. [43] the average power was in the range of 2–6 W corresponding to a LEED of 10–30 J/cm.

15.8 Costs

Although EVLA is replacing surgical stripping, proper economic evaluation is important to consider the cost of this technique. In a recent study, Disselhoff et al. [9] calculated that the costs of cryostripping and endovenous laser per patient were 2,651 and 2,783€, respectively. When comparing EVLA to high ligation and stripping (HL/S), Rasmussen et al. [38] reported that the HL/S and EVLA groups did not differ in mean time to resumption of normal physical activity (7.7 vs. 6.9 calendar days) and work (7.6 vs. 7.0 calendar days). Postoperative pain and bruising were higher in the HL/S group, but no difference in the use of analgetics was recorded. The total cost of the procedures, including lost wages, was 3,084€ ($3,948 US) in the HL/S group and 3,396€ ($4,347 US) in the EVLA group [38].

Take Home Pearls

- EVLA, when performed under tumescent local anesthesia, is clinically feasible and well tolerated for both GSVs and SSVs.
- Because the vein is accessed via a 21-gauge needle, this is a minimal invasive procedure, leaving virtually no scar on the patient's skin.
- Local cutaneous side effects, such as skin burns, which have been reported in less than 1% of EVLA procedures, can be easily avoided by injection of enough tumescent fluid.
- EVLA offers many potential advantages over conventional surgery for GSV or SSV reflux; the procedure is performed with on-table ultrasound imaging, providing safe and reliable identification of the variable anatomy.
- It is likely that the role of surgery will diminish as endovenous methods such as EVLA become more widely used.

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