Minimally invasive treatments for perforator vein insufficiency

Gokhan Kuyumcu¹, Gloria Maria Salazar², Anand Prabhakar², Suvranu Ganguli²

¹Cleveland Clinic Imaging Institute, Cleveland, OH 44195, USA; ²Division of Interventional Radiology, Department of Radiology, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, USA

Abstract: Incompetent superficial veins are the most common cause of lower extremity superficial venous reflux and varicose veins; however, incompetent or insufficient perforator veins are the most common cause of recurrent varicose veins after treatment, often unrecognized. Perforator vein insufficiency can result in pain, skin changes, and skin ulcers, and often merit intervention. Minimally invasive treatments have replaced traditional surgical treatments for incompetent perforator veins. Current minimally invasive treatment options include ultrasound guided sclerotherapy (USGS) and endovascular thermal ablation (EVTA) with either laser or radiofrequency energy sources. Advantages and disadvantages of each modality and knowledge on these treatments are required to adequately address perforator venous disease.

Keywords: Perforator vein insufficiency; endovascular thermal ablation (EVTA); ultrasound guided sclerotherapy (USGS)

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Introduction

Approximately 25% of women and 15% of men in the United States suffer from lower extremity venous insufficiency, and accordingly lower extremity venous insufficiency is responsible for significant health care expenditures in USA and worldwide (1,2). Cosmetic causes are the main reason patients seek medical treatment for varicose veins, but presentation with lower extremity venous insufficiency symptoms including aching, pain, night cramps, fatigue, heaviness, or restlessness are also common (3). Untreated significant superficial venous insufficiency may eventually progress to advanced chronic venous insufficiency, including lower extremity swelling, eczema, pigmentation, hemorrhage, and ulceration (4).

A common cause of recurrence after treatment of incompetent superficial veins is perforator vein insufficiency. Recent advances in the treatment of superficial venous insufficiency have significantly changed management in this subset of patients. Physicians specialized in treatment of venous diseases can now choose from a variety of minimally invasive techniques and treatment modalities including ultrasound guided sclerotherapy (USGS) and endovascular thermal ablation (EVTA), with either laser or radiofrequency energy sources. These techniques can be performed in an office setting with local anesthesia or with conscious sedation, unlike their surgical counterpart, subfascial endoscopic perforator surgery (SEPS) which requires general anesthesia and a hospital setting (2,5-7). Data and experience regarding minimally invasive techniques in insufficient perforator veins are increasing. These newly introduced techniques have their own advantages, disadvantages and efficiency rates, both in superficial and perforator vein use. Lack of experience and awareness of newly introduced equipment designed for perforator vein treatments may be limiting factor in widespread use.
Perforator vein anatomy and pathogenesis of incompetency

Perforator veins connect the deep and superficial venous systems, allowing passage of blood in between them. Lower extremity perforators are named depending on their topographical location. Thigh level perforators are named Hunter veins; perforators located just above and below the knee are named Dodd and Boyd veins respectively; and calf level perforators are named Cockett veins (8,9). Perforator veins run in close proximity to the arteries, but their anatomy is variable. This variability is more evident after significant dilatation and tortuosity due to insufficiency, and it may render perforator veins difficult to identify with US and difficult to access for EVTA.

Re-entry points are where superficial lower extremity veins and perforator veins join. Volume overload at reentry points may lead to weakening of the perforator vein walls, dilatation, and eventually reflux (Figure 1). Reflux within incompetent superficial veins triggers perforator veins to enlarge and become incompetent (10,11). High flow from the deep venous system during muscular contraction rendering perforating veins incompetent was a previously suggested theory, that is now widely abandoned (12,13). Perforator vein incompetence generally follows reflux within the superficial veins in a temporal fashion, supporting the former theory (9,14). Pathologic perforator veins are described as having reversed flow from deep system to superficial vein for more than 500 ms, and with diameter more than 3.5 mm. Risk factors for incompetent perforator veins are the same as for all chronic superficial venous disease, including history of deep venous thrombosis, multiple pregnancies, advanced age and genetic factors (15).

Incompetent perforator veins have been linked to chronic venous insufficiency including recurrence of superficial venous reflux after treatment, varicose veins and ulcer development. Despite the fact that compression stockings therapy is the primary treatment for chronic superficial venous disease, non-compliance amongst patients is common. Interventions to relieve venous hypertension have been shown to improve wound healing and decrease risk of recurrence (16-18). Treatment and closure of incompetent perforators minimizes long-term sequelae of chronic venous insufficiency, and reduces the rate of venous stasis ulceration. Current guidelines recommend perforator treatment in cases of clinical severity, etiology, anatomy, pathophysiology score (CEAP) 5 and 6, with treatment of the perforator at the level of previous or active venous ulceration (5,19,20). Several authors also suggest treating incompetent perforator veins in cases of focal pain, focal swelling, associated varicose veins, focal skin irritation and/or discoloration in the area of the incompetent perforator vein (21,22).

USGS

USGS uses chemical agents to treat venous perforators and is the most commonly utilized and oldest minimally invasive ablation method used (23). It offers several advantages in that the technique is relatively easy technically and less
complicated than other methods. US-guided access to the perforator vein is established; with confirmation with aspiration of blood ensure endoluminal position before ablation. Sodium morrhuate, sodium tetradecyl sulfate (STS), and aethoxysclerol are reported sclerosants in the literature (24-26). When in contact with the venous walls, these sclerosants cause denaturation of proteins, denude the endothelium, and cause direct tissue damage just beyond the vessel wall. The response is a result of this cell damage with fibroblast proliferation that leads to sclerosis and fibrosis. In addition to fibrosis, agents may produce other effects such as thrombosis, extraction of proteins from lipids, denaturation of proteins, cell dehydration by osmosis, and physical obstruction by polymerization.

Sclerotherapy with a chemical foam, where the agents are mixed with air, has been reported to be more efficacious than injection of liquid (27), as it increases the time the ablation agents are in contact with the venous walls. This technique has benefits in that it can be injected into a tortuous perforator vein or its tributary, and with proper technique, sclerose the perforator vein up to its connection with the deep system. It can also treat all varicosities in relation to an incompetent perforator with a single injection (Figure 2). USGS can be performed quickly and without expensive equipment and catheters; although, the side effect profile may be wider when compared to other minimal invasive techniques. An early closure rate of 98% and a 20-month follow-up closure rate of 78% have been reported for incompetent perforator treatment. Patients with successfully treated incompetent perforator veins also had a significant improvement in their clinical scores and symptoms, proving the clinical success of this technique (28). Several small perforators frequently accompany the dominant perforator, and Doppler US can be effective in showing these perforators in close proximity to main dilated perforator vein (29,30). These small adjacent perforators can become insufficient after an initial treatment (29), and new or recurrent perforator disease is a well-described entity. USGS can easily be repeated in these situations.

Local side effects include allergic reactions and phlebitis. Major complications include deep vein thrombosis (DVT) in the communicating deep venous system and pulmonary emboli. Case reports related to systemic embolization, including transient loss of vision and stroke have been reported (25,27,30). Close proximity of perforating veins to arteries has reported inadvertent embolization of the artery and subsequent extensive skin necrosis. This should be preventable with proper technique and confirmation of needle tip position within the vein and target vessel prior to injection or treatment. Hyperpigmentation may occur from heme trapped with the sclerosed superficial veins. Phlebectomy of the affected vein can be used to minimize this side effect (31).

**EVTA**

EVTA uses catheters equipped with radiofrequency or laser energy to thermally damage the endothelial lining of...
venous structures. EVTA has been used in superficial vein insufficiency treatment with satisfactory short and long-term results. EVTA is technically more complex than USGS. Specially designed 16- and 18-gauge cannulas are used for accessing the diseased perforator vein, often over a guidewire for endoluminal perforator access. A laser or radiofrequency fiber is then advanced coaxially through the introductory sheath. The fiber is usually placed at or just below the fascia to minimize deep vessel and nerve injury. Perivascular tumescent anesthesia is usually applied to minimize discomfort, protect surrounding tissues, and enhance device-wall apposition. Tumescent local anesthetic, pressure applied by the US probe, and Trendelenberg position can all be used to drain the perforator vein and provide better energy transmission through direct contact between the probe and perforator vein wall. The catheter is then withdrawn 1 to 2 mm between treatments, and consecutive levels of the target vein are treated depending on the length. Perforators can be focally treated at two or three different levels depending on the length of perforator. However, the deepest level of treatment should be 1–1.5 cm away from the deep venous system to minimize DVT risk. After energy delivery, pressure is applied to compress the walls of the treated perforator. Local side effects include ecchymosis, induration or paraesthesia. Rare systemic complications include DVT and pulmonary emboli (6,32,33).

For laser energy, commercially available 940-nm diode, 1,320 nm Nd:YAG and 1,470-nm microfibers can be used for perforator vein ablation (34-37). Commercially available radiofrequency probes are also available for perforator ablation treatment (Covidien, Mansfield, MA, USA). These probes have the capability of measuring impedance in the tissues as an additive security measure to real-time US visualization of the probe. An appropriate impedance value indicates endoluminal position and thermal ablative energy directed to the endothelial lining. Some treatment failures are attributed to perivascular positioning, resulting in insufficient contact with endothelial cells. Impedance value between 150 and 350 ohms indicates intraluminal placement while soft tissue placement registers higher values (18). Incompetent perforator veins can be treated in the same session as insufficient superficial vein ablation with the same equipment.

EVTA is technically more challenging than USGS; however, several studies have shown highly effective and durable closure rates, with closure rates ranging between 61% and 95% (37-40). A recent comparison between minimally invasive techniques for perforator ablation showed EVTA had better early closure rates when compared to USGS; however, this rate narrowly missed significance (40). Also, closure rates of laser and radiofrequency EVTA after failed USGS were 85% and 89% respectively. Closure rate of a second USGS after failure was reported at 50%, with thermal ablative techniques significantly better for repeat closure attempt than USGS, further indicating thermal ablation may be preferred for repeat procedures for incompetent perforators (40). BMI over 50 was reported as non-closure risk factor for all minimally invasive perforator treatments (18,40,41). Perforator size and the presence of deep vein reflux were not risk factors for non-closure (18,40).

Open surgery techniques for perforator vein disease have been mostly abandoned due to the invasiveness, possible complications, and these minimally invasive surgical substitutes. SEPS has been shown to offer the same success rate with significant decreased hospital stay and complications when compared with open surgery (42,43). However, the percutaneous treatments described here are gaining momentum as a less invasive alternative when compared to SEPS. These treatments offer several advantages in that they can be applied with local anesthesia or oral/IV sedation, and distal perforators around the malleolus are easily treatable unlike SEPS (24,32,44). These treatments are performed without incisions, and are easily repeatable if necessary. Older patients and patients with lower extremity edema and obesity can easily be treated, a usual contraindication to open surgery or SEPS (2,6,43). Both short-term and long-term closure rates at 10 years have been shown to be high and it is accepted as effective treatment for insufficient superficial veins (34,35,45). Short-term closure rates of perforator veins with minimally invasive treatment options is effective and similar to superficial vein closure rates (18).

## Conclusions

Chemical and thermal ablative technology for perforator treatment will continue to improve. USGS can be recommended as a first-line treatment before thermal ablation because it is fast, minimally painful, and less expensive when compared to other modalities. USGS is also preferable in multiple communicating perforator veins. EVTA with laser or radiofrequency energy may be recommended in patients with initial failures by USGS and for patients with possible risk factors for failure, such as obesity. However, treatment modality for insufficient
perforators is dependent on individual expertise, treatment modalities, clinical setting and patient preference.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

References


