Feasibility and safety of flush endovenous laser ablation of the great saphenous vein up to the saphenofemoral junction

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ABSTRACT

Objective: The optimal ablation distance from the catheter tip to the common femoral vein during endovenous laser ablation (EVLA) of the great saphenous vein (GSV) is a matter of debate. In this study, we evaluated the feasibility and safety of flush ablation (fEVLA) of the GSV.

Methods: This single-center, retrospective analysis of prospectively collected data included all consecutive fEVLA interventions of the GSV between September 2017 and October 2018. Interventions were performed with a 1470-nm radially emitting fiber. Primary end points were technical feasibility of fEVLA and endovenous heat-induced thrombosis (EHIT) class 2 to class 4. Secondary end points were procedure-related complications; anatomic success at week 6; and flush occlusion at day 1, day 10, and week 6.

Results: A total of 135 consecutive intended fEVLA procedures were performed in 113 patients (86 female, 27 male). The average body mass index was 24.9 ± 4.3 kg/m^2. The Clinical, Etiology, Anatomy, and Pathophysiology (CEAP) clinical class for these patients was C2 in 78 (57.8%), C3 in 48 (35.6%), C4 in 8 (5.9%), and C5 in 1 (0.7%). The GSV diameter at the saphenofemoral junction was 9.4 ± 2.7 mm with a maximum of 16 mm. In 126 cases (93.3%), concomitant treatment of tributaries with phlebectomy or foam sclerotherapy was performed. In 127 cases (94.1%), fEVLA was technically feasible; in 8 cases (5.9%), appropriate catheter tip placement was not possible. In these cases, "standard" GSV ablation 10 to 20 mm distal to the saphenofemoral junction was performed. In the remaining 127 cases, one (0.8%) EHIT class 2 and one (0.8%) EHIT class 3 developed at day 10. After a 2- to 3-week course of anticoagulation with rivaroxaban, these EHIT cases resolved without sequelae. Furthermore, one (0.8%) superficial vein thrombosis and one (0.8%) calf vein thrombosis at the site of phlebectomy were observed. No local groin complication occurred. Flush occlusion was observed in 94.5%, 95.3%, and 88.2% of the cases at day 1, day 10, and week 6, respectively. Multivariate regression analysis revealed no significant association between flush ablation at day 1 and age, body mass index, CEAP class, fiber type, maximum vein diameter, or applied joules per centimeter.

Conclusions: The results of this study suggest that fEVLA of the GSV using a radial emitting laser is feasible and seems to be safe. (J Vasc Surg: Venous and Lym Dis 2020;■:1-8.)

Keywords: Flush endovenous laser ablation; Endovenous laser ablation; Endovenous crossectomy; Great saphenous vein; Varicose veins

Freedom from recurrent varicose veins is a desired outcome of varicose vein treatment. However, current literature suggests a similar high long-term (>5 years) varicose vein recurrence rate after both high ligation and stripping (HL/S) and endovenous laser ablation (EVLA).[1-3] In particular, reported long-term recurrence (>5 years) after EVLA of the great saphenous vein (GSV) can be observed in about one-third of patients.[1,2,4] However, compared with HL/S, in which neovascularization at the groin is a frequent cause of recurrence,[5] after EVLA, a frequent source of reflux (between 8% and 31%[6]) seems to be an incompetent proximal saphenous stump communicating with junctional tributaries. The most common scenario is the propagation of the incompetence from the saphenofemoral junction (SFJ) down the anterior accessory saphenous vein.[5,7] This difference could be explained by procedural factors. During HL/S, not only the GSV, but also all tributaries at the SFJ were ligated, exactly with the purpose of reducing recurrence. During EVLA, the GSV is usually ablated up to 1 to 2 cm distal to the confluence of the GSV and the common femoral vein (CFV),[8] leaving a GSV stump to minimize possible thrombotic complications. The formation of such a postoperative thrombus at the end of the ablated

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GSV is termed endovenous heat-induced thrombosis (EHIT) and is indeed a well-recognized complication after endovenous thermal ablation procedures. Technical improvements, such as the development of radially emitting fibers, might reduce the risk of EHIT during flush EVLA (fEVLA) compared with the first-generation front-firing fibers. Furthermore, there is no study indicating that flush GSV ablation (vein ablation up to the SFJ without leaving a stump) using a radial fiber is associated with a higher risk of EHIT. For these reasons and with the hope of lowering long-term recurrence rate, fEVLA is already being performed and suggested by some authors.[9,10] Unfortunately, data on the feasibility, safety, and long-term results of flush ablation are still lacking. Therefore, the objective of this study was to determine the feasibility and safety of fEVLA of the GSV.

ARTICLE HIGHLIGHTS

- **Type of Research:** Single-center retrospective analysis of prospectively collected registry data
- **Key Findings:** Flush endovenous laser ablation technique treating the great saphenous vein showed a technical feasibility of 94.1% in 135 consecutively treated patients. One (0.8%) class 2 and one (0.8%) class 3 endovenous heat-induced thrombosis and no local groin complications were registered.
- **Take Home Message:** The data of this study suggest that flush endovenous laser ablation of the great saphenous vein using a radial emitting fiber is feasible and seems to be safe.

METHODS

Study design. This was a retrospective single-center observational study conducted in a secondary referral hospital in Switzerland between September 2017 and October 2018. The medical records of consecutive patients undergoing EVLA of the GSV were collected prospectively and then reviewed using the venous reporting standards guidelines.[11] An ethical approval was not required per local guidelines.

Preoperative evaluation. Patients with symptomatic GSV evaluated at the Ospedale Regionale di Locarno form the basis of this study. The following parameters were noted at the initial visit: patient age, sex, body mass index (BMI), venous symptoms and complications, personal and family history of venous thromboembolism, concomitant medications, physical examination findings, and duplex ultrasound results. All duplex ultrasound examinations were performed on a Logiq E9 (GE Healthcare, Wauwatosa, Wisc) in the standing position under similar environmental conditions by an experienced vascular physician. The maximum GSV diameter at the SFJ was recorded. A reflux of >0.5 second in the target vein and a CEAP clinical class between C2 and C6 assigned by the examining vascular specialist were required for endovenous therapy.

EVLA procedure. Before the procedure, written informed consent was obtained. All procedures were performed in an ambulatory office-based setting under tumescent local anesthesia. Patients were placed in the supine position. All procedures were performed with a 1470-nm-wavelength radial laser (ELVeS; Biolitec, Vienna, Austria). A 16-gauge intravenous catheter (if an ELVeS Radial slim fiber was used) or a 6F vascular sheath (if an ELVeS Radial fiber or an ELVeS Radial dual ring fiber was used) was placed under ultrasound guidance in the GSV, usually at the most distal point of reflux. The fiber tip was placed in the CFV in proximity to the SFJ to avoid distal dislocation into a tributary during tumescent anesthesia. Tumescent local anesthetic solution (500 mg prilocaine, 0.5 mg epinephrine, and 5 mL sodium bicarbonate 8.4% diluted in 500 mL lactated Ringer solution) was infiltrated along the whole length of the target vein using a 20-gauge (0.9- × 70-mm) needle under ultrasound guidance. Particular attention was given to the application of a generous amount of tumescent solution around the catheter at the SFJ to compress the GSV around the catheter. The laser catheter tip was now carefully positioned at the SFJ under ultrasound control. The correct fiber tip position was documented in the longitudinal and transverse views. If proper fiber tip placement or visualization was not possible, this was documented, and the tip was placed 1 to 2 cm distal to the SFJ. Laser energy application alongside the GSV was administered at 7 to 10 W power using a continuous setting, aiming for a linear endovenous energy density target of 60 to 80 J/cm during slow pullback of the EVLA catheter. A doubled energy amount was administered at the first 1 to 2 cm of the GSV at the SFJ region under ultrasound visualization and external compression of the GSV by the ultrasound probe. The total time and applied energy of the laser treatment were recorded. Concomitant treatment of tributaries with foam sclerotherapy or phlebectomy was performed after laser ablation. In particular, phlebectomy was performed with 2- to 3-mm incisions over varicosities using a hook (Oesch; Salzmann AG, St. Gallen, Switzerland). Ultrasound-guided foam sclerotherapy was performed with polidocanol (Aethoxysklerol; Kreussler Pharma, Wiesbaden, Germany) 1% to 2% combined with room air in a ratio of 1:4 using the Tessari double-syringe system technique. The maximum total volume of foam used per session was <10 mL in accordance with current guidelines.[12] An eccentric compression of the treated veins was applied by using sterile gauze and a full-length graduated compression stocking class II (23-32 mm Hg). In patients not receiving anticoagulation, thromboprophylaxis with rivaroxaban 10 mg daily was administered for 5 days (off-label) according to our internal algorithm.[13] The first dose was administered right after the

Table I. Kabnick classification of endovenous heat-induced thrombosis (EHIT)

Class	Criteria
1	Venous thrombosis to the saphenofemoral junction, not extending into the deep venous system
2	Nonocclusive venous thrombosis projecting to the deep venous system, whereby the cross-sectional area of thrombus in the deep vein is <50%
3	As above, but with cross-sectional area in the femoral vein of the thrombus >50%
4	Occlusive deep vein thrombosis

From Kabnick L, Ombrellino M, Agis H, Almeida J, Moritz M, Giorigio S. Endovenous heat induced thrombus (EHIT) following endovenous vein obliteration: to treat or not to treat. A new thrombotic classification. Presented at: Third International Vein Congress; Miami, Fla; April 14-16, 2005.

procedure. All patients were asked to walk immediately after the procedure and to return to normal activities as soon as they felt comfortable. A short course (3-5 days) of nonsteroidal anti-inflammatory drugs combined with a proton pump inhibitor (pantoprazole, 20 mg daily) was prescribed for all patients with no contraindications.

Follow-up. All patients were followed up on an outpatient basis for physical examination and duplex ultrasound by an experienced vascular physician at day 1, day 10, and week 6 after the procedure. At day 1, the eccentric compression dressing was removed, and the presence of possible complications, such as relevant bleeding, hematoma, dysesthesia, and superficial vein thrombosis, was recorded. Duplex ultrasound of the superficial and deep venous system was performed, assessing for successful saphenous vein ablation and deep venous thrombosis. The distance of the occluded GSV or thrombus in relation to the SFJ, named 0-point distance (0-PD), was also recorded. Compression stockings were recommended for another 2 to 3 weeks except during sleep and bathing.

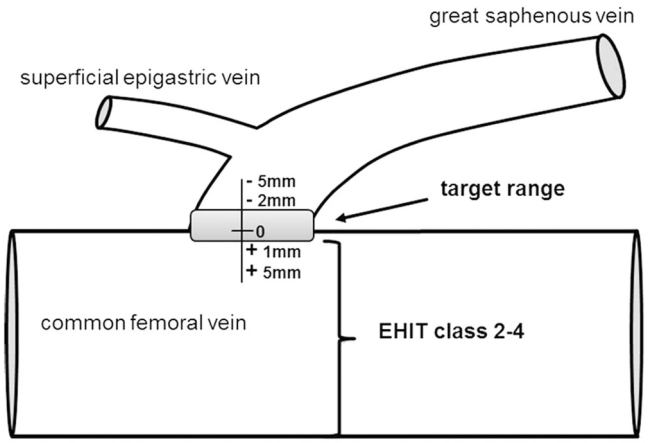

Fig 1. Ultrasound measurement of the distance between the saphenofemoral junction (SFJ; reference point 0) and the occluded great saphenous vein, named 0-point distance (0-PD). Flush ablation was defined as a 0-PD between +1 mm and −2 mm (target range). A 0-PD > +1 mm was classified as endovenous heat-induced thrombosis (*EHIT*) ≥2, and a 0-PD < −2 mm was defined as residual stump.

Definition of outcome parameters. The primary efficacy and safety end points were technical feasibility and EHIT class ≥2. Technical feasibility was defined as the ability to correctly place and to visualize in the longitudinal and transverse views the catheter tip at the SFJ after application of tumescent anesthesia. At the end of each fEVLA, a statement about feasibility was given (feasible or not feasible) and documented. EHIT classes 2 to 4 were classified as mentioned by Kabnick et al[14] (Table I) and recorded with DUS in transverse and longitudinal views at each visit. To classify EHIT, the 0-PD was measured. Given that the goal of the intervention was a flush ablation of the GSV (an occlusion up to the CFV), EHIT class 1 was omitted. Flush ablation (target range) was arbitrarily defined as a 0-PD between −2 mm and +1 mm. Values proximal to the SFJ were defined as positive, whereas values distal to the SFJ were negative (Fig 1). Distances more than −2 mm were classified as residual stump; distances more than +1 mm were classified as EHIT class 2 to class 4.

Secondary end points were procedure-related complications; anatomic success; and flush occlusion at day 1, day 10, and week 6. Procedure-related complications, such as deep venous thrombosis in locations other than the SFJ or CFV, superficial vein thrombosis, pulmonary embolism, allergy, sensory disturbance in the groin region, bleeding, and infection, were recorded. Anatomic success was categorized in complete closure (incompressibility of the GSV), partial closure (compressibility of a treated GSV segment of <5 cm), and recanalization (compressibility of a GSV segment of >5 cm).

Statistics. The distribution of summary demographic and clinical parameters was tested using the Shapiro-Wilks test and expressed as mean ± standard deviation or median ± interquartile range as appropriate. Between-group differences were assessed with the χ^2 test. The incidence of each EHIT level and the incidence of all complications are reported in absolute and relative numbers, including corresponding 95% confidence intervals. The influences of clinical and procedural parameters (ie, vein diameter) on the feasibility of fEVLA were determined using a multivariate regression analysis. Analyses were performed using SPSS version 25 software package (IBM Corp, Armonk, NY).

RESULTS

A total of 148 EVLA ablations of the GSV in 120 patients were performed between September 2017 and October 2018. Because of only segmental distal truncal

Table II. Patient demographics and limb characteristics (N = 135)

Age, years	56.7 ± 15.3
Female	104 (77)
Bilateral procedure	22 (16.3)
Right leg	67 (49.6)
BMI, kg/m^2	24.9 ± 4.3
CEAP class	
C2	78 (57.8)
C3	48 (35.6)
C4	8 (5.9)
C5	1 (0.7)
Personal history of varicose vein bleeding	5 (3.7)
Personal history of venous thromboembolism	12 (8.9)
Family history of venous thromboembolism	6 (4.4)
Oral contraceptive use (women only)	4 (3.9)
Systemic anticoagulation during the intervention	0 (0)
Known thrombophilia	0 (0)
Maximal GSV diameter in the region of the SFJ, mm	9.4 ± 2.7

BMI, Body mass index; *CEAP*, Clinical, Etiology, Anatomy, and Pathophysiology; *GSV*, great saphenous vein; *SFJ*, saphenofemoral junction. Categorical variables are presented as number (%). Continuous variables are presented as mean ± standard deviation.

insufficiency (n = 6), lack of SFJ in recurrent varicose vein treatment setting (n = 4), inability to visualize the SFJ sufficiently in an obese patient (BMI, 40.8 kg/m^2; n = 1), and proximal vein tortuosity (n = 2), flush ablation up to the SFJ was deemed not reasonable in these 13 patients. In the remaining 135 cases, flush ablation of the GSV up to the SFJ was attempted. Table II summarizes the patients' baseline demographic data. The diameter of the GSV at the SFJ was 9.4 ± 2.7 mm (range, 4-16 mm). In eight cases (5.9%), appropriate placement of the laser catheter tip at the SFJ was not achieved: in two cases, the GSV was too tortuous at the SFJ region; in one case, the SFJ could not be visualized sufficiently because of air bubbles submerged during placement of the introducer; and in five cases, the catheter tip skipped into the superficial epigastric vein during tumescence administration and proper replacement of the tip was not possible. In these cases, "standard" GSV ablation 10 to 20 mm distal to the SFJ was performed with success. Thus, in 127 of 135 cases (94.1%), proper tip placement and visualization at the SFJ were possible and a flush ablation of the GSV was performed. Procedural characteristics are summarized in Table III. On average, 72.5 ± 13.2 J/cm was administered with a mean treatment length of 47.1 ± 15.6 cm. Concomitant treatment of tributaries was performed in 128 cases (92.9%); in 110 (86.6%), concomitant phlebectomies were performed, accompanied by sclerotherapy in 17 (13.4%) of the cases. Sole concomitant sclerotherapy was carried out in eight cases (6.3%). Postprocedural compression stockings (n = 120) or compression bandages (n = 6) were applied for 21 ± 1 days, and medical thromboprophylaxis with rivaroxaban 10 mg once daily was prescribed in 125 cases (one patient refused thromboprophylaxis and preferred a homeopathic medication; one patient was prescribed low-molecular-heparin in prophylactic dose because of known rivaroxaban intolerance). Follow-up examinations at day 1, at day 10 (10.8 ± 2.8 days), and after 6 weeks (45.7 ± 6.6 days) could be performed in all 127 patients (100%). Table IV summarizes the outcome data. The sonographically observed complete occlusion rate of the GSV at 6 weeks was 94.5%. A partial occlusion was observed in the remaining cases; no complete recanalization was observed. No major bleeding complication, no infection, no nerve lesion at the groin region, and no skin burns were observed during follow-up. At day 10, one calf vein thrombosis (musculus gastrocnemius veins) at the site of phlebectomy was observed in a male patient without any known thrombotic risk factors, which resolved completely after a 6-week course of rivaroxaban 20 mg once daily. In addition, one EHIT class 3 (distance to the SFJ +25 mm) was detected 10 days after ablation of a 10-mm-diameter GSV with the dual ring catheter in a 62-year-old man, in whom rivaroxaban was paused 1 day after the intervention because of macrohematuria. Rivaroxaban was restarted (15 mg twice daily), and at a control ultrasound 2 weeks later, the thrombus regressed to +2.5 mm, and rivaroxaban was again stopped. At the 6-week follow-up examination (2 weeks later), a flush occlusion at the SFJ was observed (+1 mm). Finally, one EHIT class 2 (+2 mm at the SFJ) was detected in a female patient with a previous history of superficial vein thrombosis 10 days after dual ring ablation of a 12-mm GSV. Rivaroxaban 10 mg once daily was continued for an additional 3 weeks (in total 28 days). At the follow-up examination, the thrombus regressed, and flush occlusion (±0 mm) was observed. Fig 2 displays the 0-PD during follow-up. The mean distance of the GSV occlusion from the SFJ (0-PD) in the whole cohort was −0.7 ± 2.1 mm at day 1, −0.3 ± 3.0 mm at day 10, and −1.5 ± 3.8 mm at week 6. Flush occlusion (+1 to −2 mm) was observed in 94.5%, 95.3%, and 88.2% of the cases at day 1, day 10, and week 6, respectively. Accordingly, ablation of the GSV with a stump of ≤5 mm was achieved in 96.9%, 96.1%, and 92.1% of the cases. Flush ablation at day 1 was not significantly associated with age, sex, BMI, CEAP class, fiber type, maximum vein diameter, or applied joules per centimeter in the multivariate regression analysis (all variates $P > .2$). At week 6, flush ablation was associated with a lower BMI (24.6 vs 27.3 kg/m^2; $P = .027$) with an odds ratio of 0.84 (95% confidence interval, 0.72-0.98). The median (interquartile range)

Table III. Procedural data of the groups in which flush endovenous laser ablation (*fEVLA*) was intended and performed

Parameters	Results		*P* value
	fEVLA intended (n = 135)	fEVLA performed (n = 127)	
Treated GSV length, cm	46.7 ± 16.1	47.1 ± 15.6	.420
Catheter			.498
Dual ring	81 (60)	76 (59.8)	
Slim	37 (27)	34 (26.8)	
Ring	17 (12)	17 (13.4)	
Applied energy, joules	3668.2 ± 2819.2	3432.4 ± 1284.2	.630
Application time, seconds	445 ± 203	444.2 ± 205.1	.874
Concomitant EVLA of AASV or PASV	21 (15.5)	30 (23.6)	.951
Concomitant treatment (other than EVLA)			.733
None	9 (6.7)	9 (7.1)	
Phlebectomy	101 (74.8)	93 (73.2)	
Sclerotherapy	8 (5.9)	8 (6.3)	
Phlebectomy and sclerotherapy	17 (12.6)	17 (13.4)	

AASV, Anterior accessory saphenous vein; *GSV,* great saphenous vein; *PASV,* posterior accessory saphenous vein.
Categorical variables are presented as number (%). Continuous variables are presented as mean ± standard deviation.

change of the occlusion distance was 0 (0-0) mm from day 1 to day 10, 0 (0 to −1) mm from day 10 to 6 weeks, and 0 (0-0) mm from day 1 to 6 weeks. In 63.0% (n = 80) of the cases, the distance to the SFJ remained the same in comparing the day 1 and week 6 ultrasound examinations. In 16 cases (12.6%), a progression of the occlusion was observed; and in 31 cases (24.4%), an occlusion regression was observed. Regression analysis showed no significant association of any parameter (including maximum diameter and joules per centimeter) with the occlusion progression or regression (data not shown).

DISCUSSION

The optimal ablation distance during EVLA of the GSV is a matter of debate.[9] Given the relatively high long-term recurrence rate, often arising from junctional tributaries, a possible technical improvement to reduce such a form of recurrence could be a flush ablation. Nowadays, the new high-resolution ultrasound machines permit better visualization of the SFJ and the fiber tip, potentially permitting precise tip positioning and treatment up to the SFJ. Furthermore, compared with older front-firing laser devices, in which damage of the opposite wall of the CFV was possible, the newer radially emitting fibers allow a more precise energy application at the tip. In this study, we were specifically looking at the technical feasibility and safety of such a technique, named in this paper fEVLA.

Feasibility. Compared with the report by Hartmann,[10] our results confirm the technical feasibility of fEVLA. In fact, in this study, fEVLA was mostly technically feasible. However, at least two hindering factors have to be taken into account in performing fEVLA: insufficient visualization and difficulty in correct placement of the fiber tip. Visualization can be impaired by adiposity or by air bubbles that can originate from concomitant foam sclerotherapy or improper flushing of the introducer sheath or of the tumescence system. Furthermore, the correct fiber tip placement can be difficult in case of GSV tortuosity or if the fiber slips into tributaries (eg, the superficial epigastric vein) after tumescent anesthesia, rendering a proper replacement difficult. In our experience, to avoid the latter case, an initial placement of the catheter a few centimeters in the CFV with correction only after application of tumescent anesthesia helps to reduce the risk of such inconvenience.

EHIT. As outlined earlier, one of the major safety concerns of fEVLA is EHIT. Our results show a 1.6% incidence of EHIT, which is in line with reports after conventional endovenous thermal ablation that vary between 0% and 6%.[15-20] In a recent meta-analysis, Healy et al[21] found an EHIT class 2 to class 4 incidence of 1.4% after endovenous thermal ablation of the GSV. The combined venous thromboembolism (EHIT classes 2-4, deep venous thrombosis, and pulmonary embolism) incidence was 1.8%. Another interesting observation is that both cases of EHIT in our population were found only at the 10-day control. This is in accordance with the study of Ryer et al,[19] in which only 47% (19 patients) of the total EHIT cases were found on the initial ultrasound examination performed 24 hours after the intervention, whereas in 44%, EHIT was found only at the second ultrasound assessment 1 week after the procedure. The remaining 9% represented venous thromboembolic events not identified by the surveillance program. In our opinion, a duplex ultrasound control examination 7 to 10 days after the intervention

Table IV. Outcome data (N = 127)

	No. (%)
Closure rate (week 6 follow-up)	
Complete	120 (94.5)
Partial	7 (5.5)
Recanalization	0
Complications	
EHIT	
Class 2	1 (0.8)
Class 3	1 (0.8)
Class 4	0
Deep venous thrombosis (without involvement of the CFV)	1 (0.8)
Pulmonary embolism	0
Superficial venous thrombosis	1 (0.8)
Major bleeding	0
Skin burn or necrosis	0
Nerve lesion in the groin area	0
Infection	0

CFV, Common femoral vein; *EHIT,* endovenous heat-induced thrombosis.

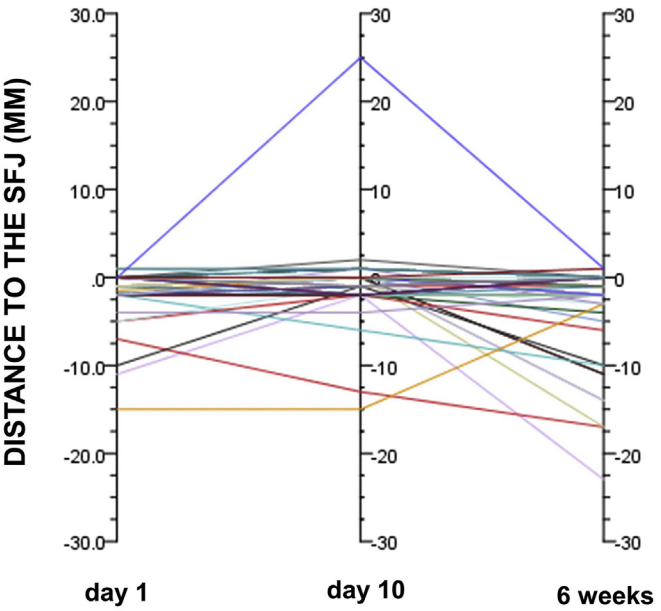

Fig 2. The 0-point distance (0-PD), the distance of the occlusion in relation to the saphenofemoral junction (*SFJ*) during follow-up. Positive values are toward the common femoral vein (CFV), and negative values are toward the great saphenous vein (GSV).

is therefore reasonable to detect such "late EHIT." Even if the full clinical relevance and natural history of this entity are not fully understood yet, some risk factors, such as concomitant phlebectomy,[22] prior venous thromboembolism,[22,23] prior superficial thrombophlebitis, larger GSV diameter,[23,24] and elevated D-dimer level with normal C reactive protein level,[25] have been associated with EHIT. An association of EHIT with the catheter tip position during endovenous thermal ablation is instead discussed in controversial fashion in the literature. Whereas Haqqani et al,[26] Sufian et al,[16] and Rhee et al[27] found no correlation between EHIT and the catheter tip position, Sadek et al[28] reported a diminished incidence of EHIT class 2 on increasing the ablation distance from 2 to 2.5 cm. We have to clarify that these data cannot be compared one to one with our results because not only the design of our study (eg, application of 5 days of rivaroxaban) but also the ablation distance (0-mm ablation distance vs 10- to 25-mm ablation distance) was different. Only future prospective randomized controlled trials will provide more reliable data to answer this question.

0-PD. A more detailed analysis of the ablated GSV at the SFJ over time shows a trend toward reduction of the "flush occlusion" group from 94.5% at day 1 to 88.2% at week 6. Only in 63% of the cases did the measured distance to the SFJ remain the same in comparing day 1 and week 6. An explanation for this dynamic process could be the formation of an appositional thrombus, which can vary during time. This observation indicates that some initially flush ablations are not based on thermal shrinkage or occlusion of the vein but represent a thrombus propagation up to the SFJ that resolves or progresses over time. The observation that patients with a higher BMI showed more regression to "stumps" possibly might be explained by the fact that the visualization of the SFJ is less optimal in these patients and the operator (unintentionally) has the tendency to apply less energy density. Whether the administration of a higher linear endovenous energy density in the first millimeters diminishes this phenomenon and how much energy finally is required are surely interesting objects to future studies.

Limitations. The limitations of this study include the lack of a control group and long-term outcome. Furthermore, the routine postinterventional thromboprophylaxis with rivaroxaban for 5 days limits the ability to generalize our findings. The strengths of this study include a uniformity in the procedure method, given that only one operator performed all interventions in a standardized fashion. A specific strength of this study is that we performed a standardized follow-up including serial high-definition ultrasound examinations and that we were able to complete follow-up in all patients (100%). This fact permits possible complications to be reliably identified and any dynamics in the ablation distance to be observed.

Looking to the future, many unanswered questions remain. Is thromboprophylaxis really needed? How much energy is required for a lasting flush occlusion? Will fEVLA effectively reduce long-term recurrence? What role does concomitant treatment of the anterior

accessory vein play, aiming to reduce recurrence? There is still a lot of work to do, but our study indicates that fEVLA is a reasonable and safe procedural option for operators aiming to potentially reduce recurrent varicose veins in their patients.

CONCLUSIONS

The results of this study suggest that fEVLA of the GSV using a radial emitting fiber is feasible and safe. Ongoing research is required to prove whether fEVLA can reduce the varicose vein recurrence rate in the future.

AUTHOR CONTRIBUTIONS

Conception and design: LS, HS, DS, HU
Analysis and interpretation: LS, HS, HK, DS, HU
Data collection: LS
Writing the article: LS, HU
Critical revision of the article: LS, HS, HK, DS, HU
Final approval of the article: LS, HS, HK, DS, HU
Statistical analysis: LS, HS, HK, DS, HU
Obtained funding: LS, DS, HU
Overall responsibility: LS

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