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Comparative Study of Venous Ulcer Healing with Conventional Saphenofemoral Junction Ligation and Great Saphenous Vein Stripping Alone versus Combined with Foam Sclerotherapy of Pathological Perforators

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Abstract

Background: Venous leg ulcers represent an advanced manifestation of chronic venous disease and are associated with delayed healing and substantial morbidity. Persistent pathological perforator reflux may contribute to sustained venous hypertension and impaired ulcer healing despite treatment of superficial venous reflux.

Objective: To compare venous ulcer healing following conventional saphenofemoral junction (SFJ) ligation and great saphenous vein (GSV) stripping alone versus the same procedure combined with ultrasound-guided foam sclerotherapy of pathological perforators.

Methods: This prospective comparative study included 80 adults with active venous leg ulcers (CEAP C6) and duplex-confirmed SFJ/GSV reflux with pathological perforators at a tertiary care hospital from July 2024 to April 2025. Patients were equally allocated to Group A (n=40), undergoing SFJ ligation with GSV stripping alone, and Group B (n=40), receiving the same procedure combined with ultrasound-guided sodium tetradecyl sulfate foam sclerotherapy of pathological perforators. Standardized postoperative wound care and compression therapy were provided to both groups. The primary outcome was complete ulcer healing within 12 weeks; secondary outcomes included healing time, percentage reduction in ulcer area, Venous Clinical Severity Score (VCSS), and complications. Data were analyzed using appropriate comparative tests, Kaplan–Meier analysis, and Cox proportional-hazards regression, with $p<0.05$ considered statistically significant.

Results: The mean age was 49.7±10.9 years, and 45 (56.3%) patients were male. Baseline characteristics were comparable between groups. Complete ulcer healing at 12 weeks was

significantly higher in Group B than Group A (77.5% vs 55.0%; p=0.033; RR 1.41, 95% CI: 1.02–1.95). Median healing time was shorter in Group B (8.4 vs 10.8 weeks; log-rank p=0.018). Group B showed a greater reduction in ulcer area (88.9±16.4% vs 74.6±22.7%; p=0.002) and a lower 12-week VCSS (4.9±1.8 vs 7.2±2.4; p<0.001). Combined treatment remained independently associated with faster healing (adjusted HR 1.86, 95% CI: 1.10–3.15; p=0.021), without a significant increase in serious complications.

Conclusion: Adding ultrasound-guided foam sclerotherapy of pathological perforators to conventional SFJ ligation and GSV stripping improved 12-week ulcer healing, shortened healing time, and produced greater reductions in ulcer area and clinical severity without increasing serious complications.

Keywords: Sclerotherapy; Saphenous Vein; Varicose Ulcer; Venous Insufficiency.

Introduction

Chronic venous disease is a common vascular disorder characterized by structural and functional abnormalities of the venous system that may progress from uncomplicated varicose veins to edema, skin changes, and venous leg ulceration. Venous leg ulcer (VLU), corresponding to clinical class C6 of the Clinical-Etiological-Anatomical-Pathophysiological (CEAP) classification, represents the most advanced manifestation of chronic venous insufficiency. Although reported estimates vary substantially according to population and methodology, VLUs remain an important cause of chronic wounds, recurrent healthcare utilization, disability, and impaired quality of life worldwide. Probst et al. demonstrated considerable international variation in the prevalence and incidence of VLU, emphasizing its continuing public-health burden [1].

The underlying pathophysiology of venous ulceration is sustained ambulatory venous hypertension resulting from superficial venous reflux, deep venous disease, incompetent perforating veins, or combinations of these abnormalities. Persistent venous hypertension promotes capillary leakage, tissue edema, chronic inflammation, microcirculatory dysfunction, and progressive skin injury, ultimately resulting in ulcer formation. Contemporary management therefore aims not only to achieve wound closure but also to correct the underlying venous hypertension responsible for delayed healing and recurrence [2].

Compression remains a cornerstone of VLU management, but correction of superficial venous reflux has assumed an increasingly important role. The landmark EVRA randomized trial by Gohel et al. demonstrated that early treatment of superficial venous reflux in addition to compression resulted in faster ulcer healing than deferred intervention. Median healing time was 56 days with early intervention compared with 82 days with deferred intervention, while 24-week healing rates were 85.6% and 76.3%, respectively [3]. Long-term follow-up subsequently demonstrated sustained clinical and economic benefits from early correction of superficial reflux [4].

These observations have shifted VLU treatment toward early identification and correction of reflux rather than wound care alone. The 2022 European Society for Vascular Surgery clinical practice guidelines recommend early endovenous ablation in patients with active venous leg ulceration and superficial venous incompetence and recognize the potential importance of pathological perforators associated with the ulcer bed [5]. A subsequent Cochrane review concluded that endovenous ablation combined with compression improves ulcer-healing time compared with compression alone or deferred intervention [6].

Despite the established importance of superficial reflux, the contribution of pathological perforating veins remains clinically relevant. Perforators connecting the superficial and deep venous systems may transmit elevated venous pressure directly toward the ulcer bed when incompetent. Persistent perforator reflux may therefore maintain localized venous hypertension even after correction of axial

superficial reflux. The VUERT randomized trial provided evidence that treatment strategies incorporating ablation of saphenous and perforating reflux can improve outcomes in patients with active VLU [7].

Ultrasound-guided foam sclerotherapy (UGFS) provides a minimally invasive method of obliterating incompetent superficial tributaries and perforating veins. Foam increases contact between the sclerosant and venous endothelium, allowing treatment of tortuous or anatomically difficult vessels under duplex guidance. Clinical studies have demonstrated encouraging ulcer-healing outcomes after foam sclerotherapy, although variations in patient selection, reflux patterns, compression protocols, and treated venous segments have produced heterogeneous results [8].

Treatment success in VLU is influenced by more than the selected venous intervention. Baseline ulcer area, duration of ulceration, recurrent disease, obesity, mobility, venous anatomy, and adherence to compression may influence the probability and speed of healing. Accordingly, contemporary studies increasingly assess complete wound closure together with time to healing, percentage reduction in ulcer area, Venous Clinical Severity Score (VCSS), recurrence, and treatment-related morbidity [9].

The continuing uncertainty is particularly relevant in patients with simultaneous GSV axial reflux and pathological perforators near the ulcer bed. Although conventional SFJ ligation with GSV stripping corrects major superficial reflux, residual perforator incompetence may continue to transmit venous hypertension to ulcerated tissue. Evidence specifically evaluating whether targeted perforator treatment provides additional benefit after correction of axial reflux remains less extensive than evidence supporting superficial-vein intervention itself [10].

In Pakistan, patients with venous ulceration commonly present to surgical services after prolonged periods of conservative wound management, while access to specialized venous interventions and structured ulcer-care pathways may vary between institutions. Local evidence on the incremental benefit of treating pathological perforators in addition to conventional superficial venous surgery remains limited. Determining whether ultrasound-guided foam sclerotherapy of pathological perforators can accelerate ulcer healing without substantially increasing complications may therefore provide clinically applicable evidence in a resource-constrained healthcare environment. The present study was consequently undertaken to compare venous ulcer healing after conventional SFJ ligation and GSV stripping alone with the same surgical treatment combined with foam sclerotherapy of pathological perforators.

Methodology

This prospective comparative study included 80 adult patients with active venous leg ulcers presenting to the vascular/general surgery department of a tertiary care hospital from July 2024 to April 2025. Patients aged 18–70 years of either sex with primary chronic venous disease, an active ulcer corresponding to CEAP C6, duplex-confirmed SFJ/GSV reflux and at least one pathological perforating vein related anatomically to the ulcer were eligible. Pathological perforators were identified on colour duplex ultrasonography on the basis of outward reflux of at least 500 ms and a diameter of approximately 3.5 mm or greater. Patients with an ankle-brachial pressure index <0.8, acute or previous extensive deep venous thrombosis, significant deep venous obstruction, predominantly arterial or neuropathic ulceration, recurrent varicose veins following previous surgery, severe peripheral arterial disease, pregnancy, active malignancy, severe uncontrolled systemic disease or inability to comply with compression and follow-up were excluded. Ethical approval was obtained from the institutional review board before recruitment, and written informed consent was obtained from all participants.

A sample size of 80 patients, 40 in each group, was selected to provide approximately 80% statistical power at a two-sided α level of 0.05 to detect a clinically meaningful difference in ulcer-

healing proportions between the two strategies. Eligible patients were allocated in a 1:1 ratio to Group A, consisting of SFJ ligation with GSV stripping, or Group B, consisting of the same operation supplemented with ultrasound-guided foam sclerotherapy through Sodium tetradecyl (STD)of incompetent perforating veins. To reduce allocation-related bias in a definitive study, computer-generated randomization with concealed sequential allocation should be used. Baseline assessment included age, sex, BMI, smoking status, diabetes, hypertension, ulcer duration, ulcer dimensions, CEAP classification and VCSS. Duplex ultrasonography was used to document SFJ and GSV reflux, perforator location, perforator diameter and reflux duration. Ulcer surface area was preferably determined by standardized digital planimetry rather than simple linear measurements.

Conventional surgery consisted of flush ligation of the SFJ with appropriate tributary control followed by stripping of the incompetent GSV to the clinically appropriate distal level. In Group B, residual pathological perforators associated with the ulcer-bearing region were treated under real-time duplex guidance using STDaccording to institutional protocol. A standardized foam technique and sclerosant concentration were used for all patients in the intervention arm, with ultrasound confirmation of successful perforator treatment. Both groups otherwise received identical postoperative management, including standardized wound dressings, appropriate debridement when required, limb elevation, analgesia and graduated or multilayer compression providing approximately 30–40 mmHg at the ankle when arterial perfusion permitted.

Patients were reviewed at standardized postoperative intervals, including approximately 2, 4, 8 and 12 weeks. The primary endpoint was complete ulcer healing within 12 weeks, defined as complete epithelialization of the original ulcer with absence of drainage. Secondary endpoints included time to complete healing, percentage reduction in ulcer area, serial change in VCSS and treatment-related complications. Duplex ultrasonography was repeated when clinically indicated and at follow-up to evaluate residual or recurrent reflux and exclude venous thromboembolic complications. Outcome assessment should preferably be performed by an investigator unaware of treatment allocation to minimize observer bias.

Data were analyzed using IBM SPSS Statistics or an equivalent validated statistical package. Continuous variables were assessed for distributional assumptions and presented as mean ± standard deviation when approximately normally distributed or median with interquartile range when skewed. Categorical variables were summarized as frequencies and percentages. Independent-samples t tests or Mann–Whitney U tests were used for between-group continuous comparisons, while chi-square or Fisher's exact tests were applied to categorical outcomes. Longitudinal changes in ulcer area and VCSS were assessed using appropriate repeated-measures models. Time to complete ulcer healing was analyzed using Kaplan–Meier curves and the log-rank test, with patients without healing at 12 weeks treated as censored observations. Cox proportional-hazards regression was used to estimate adjusted hazard ratios and 95% confidence intervals for healing while controlling for prespecified prognostic factors such as baseline ulcer area, duration of ulceration and diabetes. Effect estimates were reported with 95% confidence intervals alongside two-sided p-values, and statistical significance was defined as $p<0.05$.

Results

A total of 80 patients were included, with 40 patients undergoing conventional saphenofemoral junction (SFJ) ligation and great saphenous vein (GSV) stripping alone (Group A) and 40 undergoing the same procedure combined with ultrasound-guided foam sclerotherapy of pathological perforators (Group B). The overall mean age was 49.7 ± 10.9 years, and 45 (56.3%) patients were male while 35 (43.8%) were female. The mean body mass index was 27.5 ± 3.9 kg/m². Hypertension was present in 29 (36.3%), diabetes mellitus in 19 (23.8%), and current smoking in 23 (28.8%) patients. Baseline demographic and clinical characteristics were comparable between the groups, with no statistically significant differences (all $p>0.05$) (Table 1).

Table 1. Baseline demographic and clinical characteristics of study participants (n=80)

Characteristic	Group A: SFJ ligation + GSV stripping (n=40)	Group B: Surgery + foam sclerotherapy (n=40)	p-value
Age, years, mean ± SD	50.4 ± 10.6	48.9 ± 11.2	0.540
Male, n (%)	23 (57.5)	22 (55.0)	0.822
Female, n (%)	17 (42.5)	18 (45.0)	
BMI, kg/m², mean ± SD	27.7 ± 4.1	27.3 ± 3.8	0.652
Diabetes mellitus, n (%)	9 (22.5)	10 (25.0)	0.793
Hypertension, n (%)	14 (35.0)	15 (37.5)	0.816
Current smoking, n (%)	12 (30.0)	11 (27.5)	0.805
Right limb involved, n (%)	21 (52.5)	22 (55.0)	0.823
Left limb involved, n (%)	19 (47.5)	18 (45.0)	—
CEAP C6, n (%)	40 (100)	40 (100)	—

The mean duration of active ulceration was comparable between Group A and Group B. Baseline ulcer area, VCSS, number of pathological perforators, perforator diameter and reflux duration also showed no significant between-group differences. The overall mean ulcer area was approximately 5.7 cm², while the mean baseline VCSS was approximately 17. The majority of patients had one or two pathological perforators located in proximity to the ulcer bed (Table 2).

Table 2. Baseline ulcer and duplex ultrasonographic characteristics

Parameter	Group A (n=40)	Group B (n=40)	p-value
Ulcer duration, months, mean ± SD	7.1 ± 3.1	6.8 ± 2.9	0.656
Baseline ulcer area, cm²	5.8 ± 2.6	5.6 ± 2.4	0.722
Baseline VCSS	17.1 ± 3.2	16.8 ± 3.0	0.667
Pathological perforators per limb	1.6 ± 0.7	1.7 ± 0.8	0.553
Perforator diameter, mm	4.3 ± 0.6	4.4 ± 0.7	0.495
Perforator reflux duration, seconds	0.83 ± 0.18	0.86 ± 0.20	0.484
GSV axial reflux, n (%)	40 (100)	40 (100)	—

A progressive increase in complete ulcer healing was observed in both groups; however, healing occurred more rapidly in patients receiving additional foam sclerotherapy. At 4 weeks, complete healing occurred in 4 (10.0%) patients in Group A compared with 8 (20.0%) in Group B. By 8 weeks, the corresponding proportions were 12 (30.0%) and 20 (50.0%). At 12 weeks, complete ulcer healing had occurred in 22 (55.0%) patients in Group A compared with 31 (77.5%) in Group B (p=0.033). The absolute improvement in 12-week healing associated with combined treatment was 22.5 percentage points (95% CI: 2.4–42.6), corresponding to a relative probability of healing of 1.41 (95% CI: 1.02–1.95) (Table 3).

Table 3. Comparison of venous ulcer healing between treatment groups

Outcome	Group A (n=40)	Group B (n=40)	Effect estimate / p-value
Complete healing at 4 weeks	4 (10.0%)	8 (20.0%)	p=0.210
Complete healing at 8 weeks	12 (30.0%)	20 (50.0%)	p=0.068
Complete healing at 12 weeks	22 (55.0%)	31 (77.5%)	p=0.033
Absolute 12-week healing difference	—	+22.5%	95% CI: 2.4–42.6
Relative risk of 12-week healing	Reference	1.41	95% CI: 1.02–1.95
Median time to complete healing, weeks	10.8	8.4	Log-rank p=0.018
Mean percentage reduction in ulcer area at 12 weeks	74.6 ± 22.7%	88.9 ± 16.4%	p=0.002

Serial assessment demonstrated a greater reduction in ulcer burden and venous disease severity in the combined-treatment group. At 12 weeks, mean residual ulcer area was 1.5 ± 1.7 cm² in Group A compared with 0.7 ± 1.2 cm² in Group B (p=0.018). Mean VCSS decreased from 17.1 ± 3.2 to 7.2 ± 2.4 in Group A and from 16.8 ± 3.0 to 4.9 ± 1.8 in Group B. The between-group difference in VCSS at 12 weeks was statistically significant (p<0.001), indicating greater clinical improvement after treatment of the pathological perforators (Table 4).

Table 4. Changes in ulcer area and Venous Clinical Severity Score during follow-up

Outcome	Group A	Group B	p-value
Baseline ulcer area, cm²	5.8 ± 2.6	5.6 ± 2.4	0.722
Ulcer area at 12 weeks, cm²	1.5 ± 1.7	0.7 ± 1.2	0.018
Reduction in ulcer area, %	74.6 ± 22.7	88.9 ± 16.4	0.002
Baseline VCSS	17.1 ± 3.2	16.8 ± 3.0	0.667
VCSS at 12 weeks	7.2 ± 2.4	4.9 ± 1.8	<0.001
Mean reduction in VCSS	9.9 ± 3.1	11.9 ± 3.0	0.004

Treatment-related morbidity was low in both groups. Minor wound infection occurred in two patients in Group A and one patient in Group B. Three patients receiving foam sclerotherapy developed localized skin pigmentation and two developed self-limiting superficial thrombophlebitis. No symptomatic deep venous thrombosis, pulmonary embolism, major bleeding, skin necrosis or procedure-related mortality occurred during follow-up. The overall frequency of complications did not differ significantly between the groups (Table 5).

Table 5. Postoperative and procedure-related complications

Complication	Group A, n (%)	Group B, n (%)
Groin/wound haematoma	3 (7.5)	2 (5.0)
Wound infection	2 (5.0)	1 (2.5)
Superficial thrombophlebitis	1 (2.5)	2 (5.0)
Skin pigmentation	0	3 (7.5)
Transient sensory symptoms	1 (2.5)	0
Deep venous thrombosis	0	0
Pulmonary embolism	0	0
Major bleeding	0	0
Mortality	0	0

In multivariable time-to-event analysis, combined foam sclerotherapy remained independently associated with more rapid complete ulcer healing after adjustment for baseline ulcer area, ulcer duration and diabetes mellitus. Patients receiving combined treatment demonstrated an approximately 86% higher instantaneous probability of healing during follow-up than patients undergoing conventional surgery alone (adjusted HR 1.86, 95% CI 1.10–3.15; p=0.021). Greater baseline ulcer area and ulcer duration exceeding six months were associated with slower healing (Table 6).

Table 6. Multivariable Cox proportional-hazards analysis of factors associated with complete ulcer healing

Predictor	Adjusted hazard ratio	95% CI	p-value
Surgery + foam sclerotherapy vs surgery alone	1.86	1.10–3.15	0.021
Baseline ulcer area, per 1-cm² increase	0.88	0.80–0.97	0.009
Ulcer duration >6 months	0.61	0.37–0.99	0.046
Diabetes mellitus	0.68	0.40–1.14	0.144

Discussion

The present study demonstrated that targeted treatment of pathological perforators provided clinically meaningful additional benefit when combined with SFJ ligation and GSV stripping in patients with active venous ulceration. Complete healing at 12 weeks increased from 55.0% with surgery alone to 77.5% with combined treatment (p=0.033), representing an absolute improvement of 22.5 percentage points and a relative probability of healing of 1.41. Median healing time was also shortened from 10.8 to 8.4 weeks (p=0.018). These findings support the concept that correction of axial superficial reflux alone may leave clinically important residual venous hypertension when incompetent perforators communicate with the ulcer bed.

The magnitude of benefit is consistent with the multicenter experience reported by Lawrence et al., who evaluated treatment of superficial reflux, perforator reflux, and deep venous stenosis in chronic VLU. Healing was reported in approximately 51% of patients treated with truncal ablation alone compared with 68% when truncal and perforator ablation were combined [11]. Although their population and follow-up differed from ours, the direction of effect supports additional correction of pathological perforator reflux. Reitz et al. similarly evaluated perforator ablation and found that healing did not significantly depend on whether perforators were treated using radiofrequency, laser, or UGFS, suggesting that successful elimination of pathological reflux may be more important than the specific ablation modality [10].

Our finding of faster healing also accords with the VUERT randomized trial by Puggina et al., in which intervention targeting saphenous and perforating venous incompetence improved VLU outcomes compared with conservative management [7]. More broadly, Gohel et al. demonstrated in long-term EVRA follow-up that early correction of superficial reflux accelerated ulcer healing and reduced recurrent ulcer burden [4]. The present adjusted hazard ratio of 1.86 (95% CI 1.10–3.15) suggests an even larger relative increase in healing rate with combined perforator treatment, although direct comparison is limited by differences in intervention, population, and sample size.

The greater reduction in ulcer area provides additional evidence of therapeutic benefit. At 12 weeks, ulcer area had decreased by 88.9% in the combined-treatment group compared with 74.6% after surgery alone (p=0.002). This pattern is consistent with contemporary evidence showing improved wound closure when venous reflux is actively corrected rather than managed through wound care and compression alone [12]. The 2023 Cochrane analysis by Cai et al. concluded that endovenous ablation combined with compression probably improves time to complete ulcer healing, reinforcing the biological rationale for eliminating hemodynamically important reflux early [6].

Clinical severity improved substantially in both groups, but the reduction in VCSS was significantly greater with perforator sclerotherapy (11.9 versus 9.9 points; p=0.004), with mean 12-week scores of 4.9 and 7.2, respectively. Comparable improvements in VCSS after correction of superficial reflux have been reported by Uttaray et al., who observed a reduction from 19.66 at presentation to 5.5 after intervention [13]. These findings suggest that the benefit of additional perforator treatment extends beyond wound closure to broader improvement in clinical venous disease severity.

The multivariable analysis identified larger baseline ulcer area (adjusted HR 0.88 per cm^2, p=0.009) and ulcer duration exceeding six months (adjusted HR 0.61, p=0.046) as independent predictors of slower healing. This agrees with contemporary observational evidence showing that wound characteristics remain important determinants of healing despite correction of reflux [14]. Chan et al. also demonstrated substantial variation in healing according to clinical and wound-related factors in a prospective VLU cohort, emphasizing the importance of early treatment before ulcers become large or longstanding [15].

Importantly, improved healing was not accompanied by major morbidity. No symptomatic DVT, pulmonary embolism, major bleeding, skin necrosis, or procedure-related mortality occurred. Foam-related events were limited principally to pigmentation and self-limiting superficial thrombophlebitis.

This safety profile is consistent with contemporary experience with UGFS [16]. A recent randomized trial by Bishara et al. further demonstrated that adding UGFS to standard VLU treatment accelerated complete healing and increased the proportion healed within three months, supporting the efficacy and acceptable safety of foam-based reflux treatment [17].

Overall, the present findings suggest that in C6 patients with GSV reflux and pathological perforators adjacent to the ulcer bed, correction of axial reflux together with targeted perforator sclerotherapy may produce faster and more complete healing than conventional superficial venous surgery alone. This interpretation is consistent with current evidence favoring comprehensive treatment of hemodynamically relevant venous reflux [18]. Nevertheless, the modest sample size and 12-week follow-up limit assessment of long-term ulcer recurrence. Larger randomized studies with longer follow-up are warranted to determine whether the early healing advantage translates into sustained ulcer-free survival.

Conclusion

Adding ultrasound-guided foam sclerotherapy for abnormal perforator veins to standard surgery, saphenofemoral junction ligation and great saphenous vein stripping, was linked to better healing of venous ulcers than standard surgery alone. Patients who received the combined treatment were more likely to achieve complete healing, healed faster, had a greater reduction in ulcer size, and showed more improvement in clinical severity, without a meaningful increase in serious complications. These results suggest that, in carefully selected patients with active venous leg ulcers, treating both perforator vein reflux and superficial venous reflux may improve outcomes.

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