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Comparison of Radiofrequency Ablation and High Ligation Stripping for Varicose Veins: A Retrospective Analysis

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Running head：

RFA vs HLS for Varicose Veins

Abstract

Objective: To compare the clinical efficacy, postoperative complications, and quality-of-life outcomes of ultrasound-guided radiofrequency ablation (RFA) combined with tributary phlebectomy and foam sclerotherapy versus high ligation and stripping (HLS) combined with tributary phlebectomy.

Design： A single-center retrospective cohort study.

Methods: We retrospectively analyzed 2,740 patients (1,588 women; mean age 59.01 ± 12.03 years) treated between October 2020 and October 2023. Among them, 1,756 (64.1%) underwent RFA and 984 (35.9%) underwent HLS. We assessed immediate success rate, 12-month recanalization, symptomatic recurrence, reintervention rate, and complications; The AVVQ and CIVIQ-14 scores were used to evaluate quality of life (QoL), while the VCSS was used to assess disease severity at 1, 6, and 12 months postoperatively.

Results: Immediate success was achieved in both groups. At 12 months, the RFA group had 7 recanalizations (0.40%) versus 0 in the HLS group (P=0.112); symptomatic recurrence was 0.17% vs. 0.20% (P=1.000); reintervention rate was 2.62% vs. 3.05% (P=0.064); and each group had 2 cases of deep vein thrombosis. Minor complications in the HLS group included bruising (25.20% vs. 20.16%, P=0.002), pain (25.41% vs. 20.39%, P=0.002), and numbness (10.98% vs. 3.30%, P<0.001); the RFA group had higher induration (17.20% vs. 3.25%, P<0.001) and pigmentation (2.62% vs. 0.81%, P=0.001). Both groups showed significant improvements in

AVVQ, VCSS, and CIVIQ-14 scores (P<0.05), with the RFA group demonstrating greater early improvement at 1 month.

Conclusion: Ultrasound-guided RFA with foam sclerotherapy reduces minor complications such as pain, bruising, and numbness and significantly improves early quality of life, though it carries a higher risk of induration and pigmentation. Both RFA and HLS offer good long-term efficacy and low recurrence rates; treatment should be individualized based on patient condition and recovery needs.

Keywords: Great saphenous vein incompetence, Varicose veins, Radiofrequency ablation, High ligation and stripping.

Introduction

Surgical intervention remains a cornerstone of treatment for lower limb varicose veins[1]. Traditional high ligation and stripping (HLS) has been widely used but is associated with longer recovery and complications such as bruising, pain, and numbness[2]. These drawbacks often result in prolonged rehabilitation and disrupted daily life.

Advancements in medical technology have led to the rise of minimally invasive treatments like radiofrequency ablation (RFA). Studies have demonstrated RFA's benefits, including fewer complications, faster recovery, and higher patient satisfaction compared to HLS[3].

This study retrospectively compares the clinical efficacy, complications, and quality-of-life outcomes of RFA combined with tributary phlebectomy and foam sclerotherapy versus HLS combined with tributary phlebectomy in treating great saphenous vein varices. The findings aim to guide treatment decisions tailored to individual patient needs.

Methods

Study Design

This was a retrospective cohort study including 2,740 patients who underwent treatment for primary great saphenous vein (GSV) varices at the Vascular Surgery Department of Affiliated Hospital of Chengdu University of Traditional Chinese

Medicine between October 2020 and October 2023(Figure 1). The study was approved by the institutional medical ethics committee (2024KL-149) and registered at ClinicalTrials.gov (NCT05654233), in accordance with the Declaration of Helsinki.

Inclusion and Exclusion Criteria

Patients aged 18–80 years with clinical-etiological-anatomical-pathophysiological (CEAP) classification C2–C6 and duplex ultrasound (DUS)-confirmed GSV reflux time ≥500 ms with a vessel diameter ≥3 mm were included. Exclusion criteria were: severe deep venous abnormalities, deep vein thrombosis, coagulation disorders, significant limb ischemia (ankle-brachial index <0.8), pregnancy or lactation, pacemaker or defibrillator implantation, or long-term anticoagulant therapy.

Surgical Overview

All patients underwent preoperative DUS evaluation for individualized treatment planning. GSV depth was assessed preoperatively, with a depth ≥5 mm favoring the use of RFA to minimize the risk of thermal injury. In clinical practice, anesthesia type was determined based on both procedural requirements and patient preference. RFA was usually performed under local anesthesia, but general anesthesia was used when required. HLS was commonly performed under general anesthesia, although selected patients with mild disease underwent the procedure under local anesthesia.Informed consent was obtained after detailed discussion of benefits, risks, and potential complications. Varicose veins (VVs) and incompetent perforator veins (defined as

reflux ≥500 ms and diameter ≥3.5 mm) were marked, and the GSV trunk and its major tributaries were mapped using DUS guidance.

Radiofrequency Ablation (RFA)： An 18G puncture needle accessed the GSV trunk at the knee, followed by a 7F short sheath. A ClosureFast CF7-7-60 radiofrequency catheter (Medtronic, USA) was advanced to 2 cm distal to the saphenofemoral junction (SFJ). Under DUS guidance, tumescent anesthesia (normal saline mixed with lidocaine, sodium bicarbonate, and epinephrine) was injected circumferentially to compress the vein and protect surrounding tissues. In Trendelenburg position, segmental ablation was performed using 20-second heating cycles per Medtronic ClosureFast protocol, with manual compression applied to ensure uniform vein contact. Post-ablation, foam sclerotherapy (lauromacrogol: air = 1:3, maximum dose ≤4 mL per patient) was administered to tributary varices under ultrasound guidance to confirm foam distribution. Additional varices were excised using venous microhooks, and wounds were sealed with sterile 3M tape.

High Ligation and Saphenous Vein Stripping (HLS)： In Trendelenburg position, a 3 cm incision below the inguinal ligament exposed the GSV trunk at the saphenofemoral junction. Branches were ligated, the GSV was transected 0.5 cm below the SFJ, and the junction was double-ligated. A venous stripper was inserted retrograde from the distal thigh. A 1–2 cm incision 5–10 cm below the knee (or the most distal accessible point for tortuous veins) exposed, transected, and ligated the distal GSV trunk, followed by stripper withdrawal to remove the proximal GSV

segment above the knee. After stripping, pressure was applied for 3 minutes, additional varices were removed with venous microhooks, and wounds were sutured.

All procedures were performed by three experienced vascular surgeons. Immediate postoperative DUS was used to assess venous occlusion. Patients were instructed to wear sterile compressive bandages (Lohmann & Rauscher, Germany) for 48 hours and were typically discharged within 1–3 days. They were then advised to wear medical compression stockings for one month and to avoid strenuous activity or heavy lifting.

Follow-up

Primary outcomes: included 12-month GSV recanalization (defined as DUS-confirmed lumen reopening ≥5 cm with reflux ≥500 ms), symptomatic recurrence (assessed through clinical follow-up and patient-reported symptoms), and sclerotherapy reintervention (required due to subclinical recurrence).

Secondary outcomes: included procedure-related complications at 12 months, classified as severe (e.g., deep vein thrombosis, thrombophlebitis) or minor (e.g., ecchymosis, induration, pain, numbness, edema, pigmentation), as well as quality-of-life (QoL) scores (AVVQ and CIVIQ-14 GIS) and disease severity (VCSS), evaluated at 1, 6, and 12 months postoperatively.

Statistical Analysis

Statistical analysis was performed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). A P-value < 0.05 was considered statistically significant. Categorical variables were expressed as frequency and percentage, and comparisons were made using Pearson's chi-square or continuity-corrected chi-square tests. Continuous variables were tested for normality using the Kolmogorov-Smirnov test. Normally distributed data were presented as mean ± standard deviation (SD) and compared using independent-sample t-tests. Non-normally distributed variables were reported as median and interquartile range (IQR) and analyzed using the Mann-Whitney U test.

Results

Baseline Characteristics (Table 1)

Among the 2,740 patients included in the study, 1,756 (64.09%) underwent RFA and 984 (35.91%) received HLS. The RFA group had a slightly younger mean age (58.35 ± 12.61 vs. 60.20 ± 10.84 years) and a higher proportion of female patients (62.41% vs. 50.00%). Bilateral disease was more frequent in the HLS group (46.95% vs. 30.98%), and CEAP C4–C6 classification was also more common. The mean operative time was shorter in the RFA group (37.52 ± 12.81 min) than in the HLS group (44.63 ± 14.64 min).Local anesthesia was more common in the RFA group(72.41%), while general anesthesia predominated in the HLS group(95.93%), reflecting institutional preferences and patient-specific factors.

Primary Efficacy Outcomes (Table 2)

At 12 months, GSV recanalization occurred in 7 patients (0.40%) in the RFA group, while no recanalization was observed in the HLS group (P = 0.112). Symptomatic recurrence was rare in both groups, with a rate of 0.17% in the RFA group and 0.20% in the HLS group (P = 1.000). The reintervention rate using foam sclerotherapy was 2.05% in the RFA group and 3.56% in the HLS group, showing no statistically significant difference (P = 0.064).

Complications (Table 3)

Severe complications were uncommon in both groups. Deep vein thrombosis (DVT) occurred in 2 patients in each group (<0.20%, P = 0.947), and superficial thrombophlebitis was observed in 3.08% of patients in the RFA group and 2.03% in the HLS group (P = 0.106). No cases of pulmonary embolism or transient ischemic attack were reported.

Minor complications showed significant differences between the two groups. The incidence of ecchymosis was higher in the HLS group (25.20%) compared to the RFA group (20.16%) (P = 0.002). Pain was also more frequent in the HLS group (25.41% vs. 20.39%, P = 0.002), as was numbness (10.98% vs. 3.30%, P < 0.001), likely due to traction or nerve injury during stripping. On the other hand, the RFA group exhibited higher rates of induration (17.20% vs. 3.25%, P < 0.001) and pigmentation (2.62% vs. 0.81%, P = 0.001), which may be related to localized inflammatory responses and superficial thermal injury. There were no significant

differences between the two groups in the incidence of postoperative edema (14.81% vs. 15.04%, P = 0.869), and the overall rate of complications remained low.

Comparison of VCSS, AVVQ, and CIVIQ-14 scores (Table 4, Figure 2)

Significant improvements were observed in all scores across both groups ($P < 0.05$). At 1-month follow-up, the RFA group demonstrated greater improvements in quality-of-life measures, including lower CIVIQ-14 scores (8.88 ± 4.27 vs. 9.64 ± 6.08, $P < 0.001$) and AVVQ scores (3.95 ± 1.26 vs. 4.19 ± 2.04, $P = 0.001$). These differences diminished at 6 and 12 months. By later time points, VCSS and both QoL scores (CIVIQ-14 and AVVQ) were comparable between the two groups (all $P > 0.05$).

Discussion

This single-center retrospective cohort study compared the clinical efficacy and safety of radiofrequency ablation (RFA) versus high ligation and saphenous vein stripping (HLS) in the treatment of primary great saphenous vein (GSV) varices. Although the two techniques demonstrated no significant differences in 12-month venous occlusion or symptomatic recurrence rates, they differed in complication profiles and quality-of-life trajectories—providing valuable insights for individualized clinical decision-making.

Efficacy Differences and Clinical Applicability: In terms of efficacy, the HLS group achieved a 0% recanalization rate by anatomically removing the GSV trunk

(including precise ligation of the saphenofemoral junction and complete stripping), eliminating the structural basis for vascular recanalization at the anatomical level. In contrast, RFA induces vascular endothelial fibrosis and closure through endoluminal thermal injury, which may lead to a very low probability of lumen recanalization (0.40%) due to hemodynamic stress (such as long-term standing-induced venous hypertension) or insufficient ablation segment length (2 cm below the saphenofemoral junction)[4]. This difference reflects procedural differences but does not imply superiority, particularly given the influence of baseline characteristics and treatment selection patterns.In our cohort, HLS was more frequently performed in patients with CEAP classification C4–C6, combined deep venous reflux, or larger vascular diameters, which likely reflects surgeon preference for traditional surgery in more severe or complex cases[5]. Considering the baseline characteristics that the HLS group had a higher mean age and a higher proportion of bilateral lesions (46.95% vs. 30.98% in the RFA group), this may represent a selection bias inherent in retrospective designs, rather than evidence of treatment superiority[6].Both groups had extremely low symptomatic recurrence rates (0.17% vs. 0.20%), indicating reliable long-term symptom control with both methods. It is worth noting that the sclerotherapy reintervention rate in the HLS group (3.56%) was slightly higher than that in the RFA group (2.05%), which may imply a higher subclinical recurrence risk in the traditional surgical group. Many patients in the HLS group required postoperative supplementary foam sclerotherapy due to unrelieved symptoms such as pruritus and eczema. In contrast, the RFA group used intraoperative combined foam

sclerotherapy, which more thoroughly relieves such symptoms, consistent with the recommendation in many literatures to use RFA as the preferred strategy combined with foam sclerotherapy[7]8[8].

Analysis of Complications and Mechanisms: Regarding complications, both groups had extremely low and non-significant incidences of severe complications (deep vein thrombosis, pulmonary embolism), reflecting the safety of both techniques[9]. The incidence of superficial thrombophlebitis (ST) was slightly higher in the RFA group (3.08% vs. 2.03%, P=0.106), possibly related to local inflammatory reactions caused by endoluminal thermal injury. Therefore, clinical operations should pay particular attention to optimizing radiofrequency energy parameters and using tumescent anesthesia for isolation. Ultrasound-guided precise tumescent fluid injection is crucial[10]. The incidence of saphenous nerve injury-related numbness in the HLS group (10.98%) was significantly higher than that in the RFA group (3.30%), related to the anatomical feature that the saphenous nerve closely accompanies the GSV from the adductor canal to the medial malleolus. During open surgery, mechanical traction or electrocoagulation hemostasis may damage the 1-2mm diameter saphenous nerve branches[11]. Differences in postoperative pain (25.41% vs. 20.39%) and ecchymosis (25.20% vs. 20.16%) reflected that open incisions caused higher soft tissue trauma stress and vascular stump bleeding risk than endoluminal treatment[12]. During GSV stripping, the saphenous nerve is prone to mechanical injury, while thermal ablation minimizes this risk through non-anatomical endoluminal closure and tumescent anesthesia isolation[13]. However, the RFA group

had significantly higher incidences of induration (17.20% vs. 3.25%) and pigmentation (2.62% vs. 0.81%). Induration is an inherent limitation of thermal and chemical ablation for superficial GSV segments and their branches, particularly in areas with suprafascial tributaries or inadequate tissue buffering[14]. This reaction likely reflects localized thrombophlebitis and subcutaneous inflammation from sclerosant leakage or thermal injury. Although some patients may experience transient mild pain, induration typically resolves spontaneously within 1–6 months postoperatively[15]. Pigmentation is attributed to hemosiderin deposition from erythrocyte extravasation or chronic inflammation, especially in areas where foam sclerosant contacts superficial skin or subdermal plexus[16]. Improved injection control under ultrasound and limiting superficial ablation length may help reduce this risk.

Postoperative assessments showed significant improvements in both quality-of-life scores (AVVQ, CIVIQ-14) and clinical severity scores (VCSS) in both groups ($P < 0.001$). The RFA group had significantly greater improvements in CIVIQ-14 scores (11.45±6.33 vs. 9.96±10.50, $P<0.001$) and faster AVVQ symptom relief (1.94±3.53 vs. 1.56±3.03, $P=0.001$) at 1 month postoperatively, reflecting the dual advantages of minimally invasive treatment in early postoperative physical function recovery and relief of lower limb discomfort. Smaller surgical trauma and shorter recovery time make it particularly suitable for individuals with high rehabilitation efficiency requirements (such as young patients and those with urgent occupational needs)[17]. By 6 and 12 months, however, quality-of-life outcomes were comparable between the groups, suggesting that long-term recovery is equivalent

regardless of the intervention method, though early postoperative experience may differ significantly.

Clinical Application Strategies and Patient Stratification: The findings of this study align with the 2023 SVS/AVF/AVLS clinical practice guidelines[18], which advocate for minimally invasive treatments as first-line options. However, treatment decisions should be tailored to individual patient characteristics in clinical practice. For patients with mild to moderate lesions (CEAP C2-C3) who pursue rapid recovery, especially young individuals, female patients, or those sensitive to postoperative pain, RFA is the preferred option due to its minimally invasive advantages, and its application in day surgery can significantly enhance the patient experience. In clinical practice, HLS is often selected for patients with skin trophic disorders (CEAP C4–C6), concomitant deep venous reflux, or complex vascular anatomy. This reflects a tendency to reserve more invasive procedures for more advanced disease; however, the retrospective nature of this study and the non-randomized group assignment preclude definitive conclusions regarding the superiority of HLS in this subgroup. While complete stripping may theoretically reduce anatomic sources of recurrence, further prospective studies are required to confirm its clinical benefits over minimally invasive techniques in severe disease presentations.These findings support individualized treatment selection based on patient-specific factors such as lesion severity, anatomy, and recovery expectations.

Study Limitations: This study has certain limitations. First, the retrospective design may lead to selection bias (e.g., the HLS group included more severe patients), which requires further verification by prospective randomized controlled trials. Second, the follow-up time was only 12 months, lacking evaluation of long-term recurrence (such as over 5 years) and late complications (such as neoplasm formation). Additionally, the study did not include a cost-benefit analysis, and the high initial cost of RFA equipment may affect its promotion in resource-limited areas, which needs to be supplemented in future research.

Conclusion

This study confirms that both RFA and HLS are effective therapeutic options for primary great saphenous vein varices. However, each method has distinct clinical indications. RFA is better suited for patients with mild to moderate disease or those seeking faster postoperative recovery due to its minimally invasive nature. In contrast, HLS remains a valuable approach for patients with complex anatomy or advanced disease severity.

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Author's contribution

Lifeng Zhang,Wei Zeng,Caijuan Geng: Conception and design of the study.Yu Xie: Writing the original draft.Yu Xie, Yao Lin, Yuqian Xie, Junyu Zhang, Caijuan Geng: Collection, management and analysis of data.Wei Zeng: Supervision, Review and approval of the manuscript.

Declaration of conflicting interests

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Ethical approval

This study has been approved by the ethics committee of Hospital of ChengduUniversity of Traditional Chinese Medicine (Approval No: 2024KL-149).

Guarantor

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Figure 1. Flow diagram of screening and follow-up

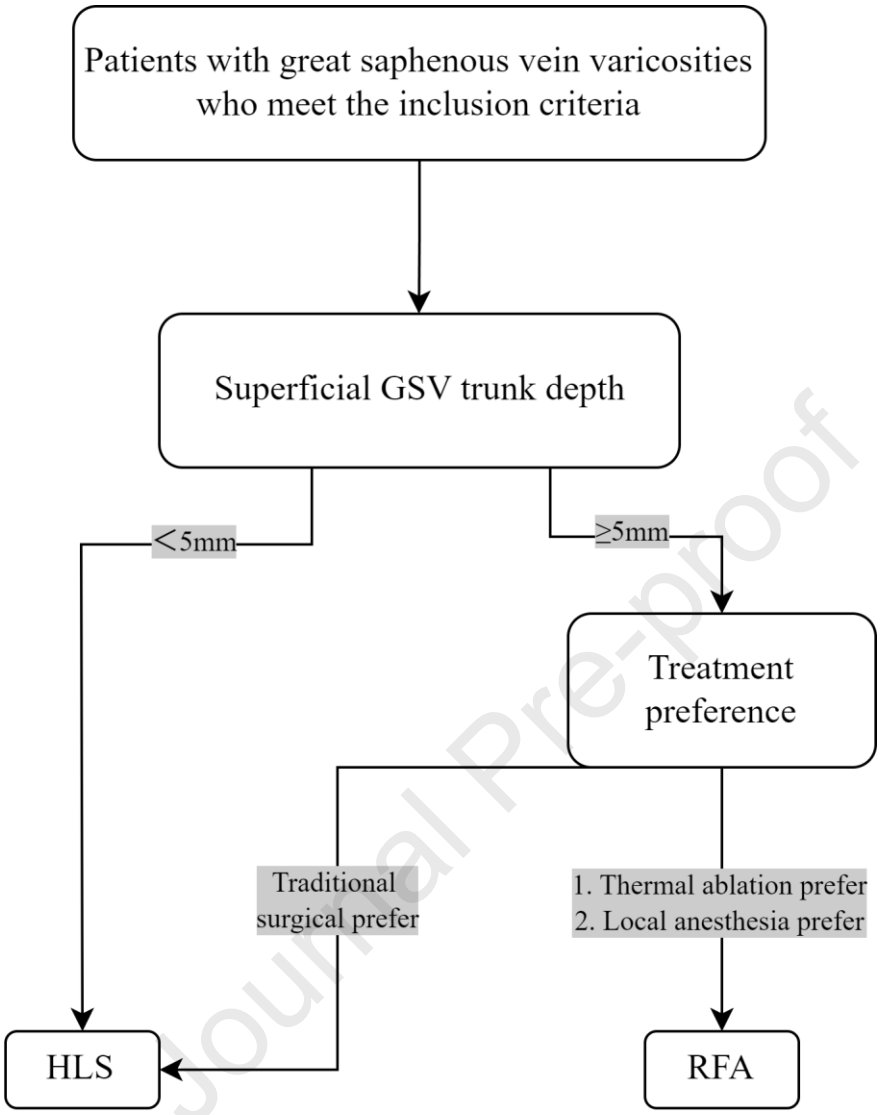

Figure 2. The QoL was measured by the Aberdeen varicose vein questionnaire (AVVQ) (a) and chronic venous insufficiency quality of life questionnaire (CIVIQ 14) (b) scores for patients treated with the RFA or HLS procedure. Compared with the baseline QoL scores, the postprocedure scores were improved following both procedures ($p < 0.05$). The venous clinical severity score (VCSS) (c) was lower postprocedure than at baseline ($p < 0.05$).

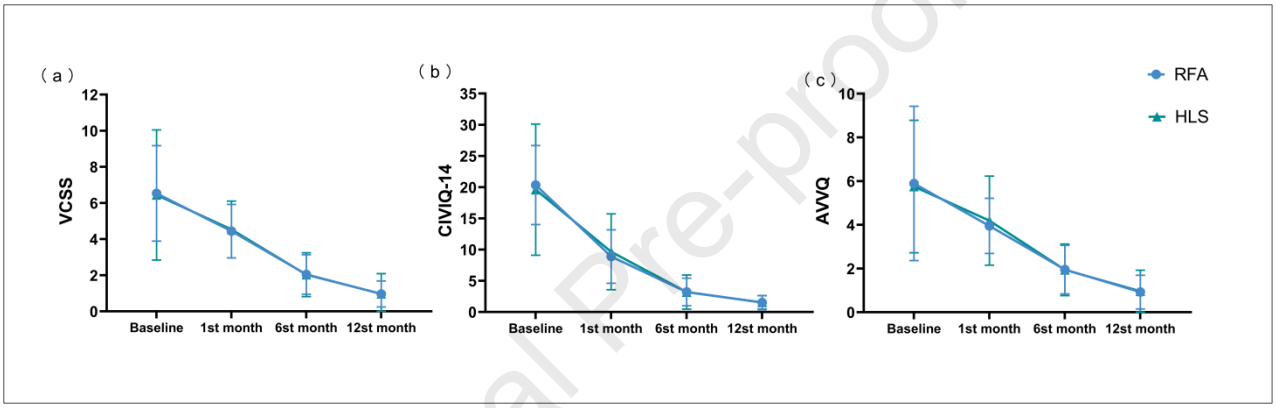

Table 1. Baseline characteristics

		Total (n = 2740)	RFA (n = 1756)	HLS (n = 984)
Age		59.01 ± 12.03	58.35 ± 12.61	60.20 ± 10.84
BMI		24.33 ± 3.33	24.19 ± 3.36	24.58 ± 3.25
OP time		40.57 ± 14.07	37.52 ± 12.81	44.63 ± 14.64
Gender(female)		1588 (57.96)	1096 (62.41)	492 (50.00)
CEAP	**C2**	926 (33.80)	582 (33.14)	344 (34.96)
	C3	796 (29.05)	556 (31.66)	240 (24.39)
	C4	886 (32.34)	544 (30.98)	342 (34.76)
	C5	64 (2.34)	34 (1.94)	30 (3.05)
	C6	68 (2.48)	40 (2.28)	28 (2.85)
Limbs(Both legs)		1006 (36.72)	544 (30.98)	462 (46.95)
Anesthesia	**General**	1428 (52.15)	484 (27.59)	944 (95.93)
	Local	1310 (47.85)	1270 (72.41)	40 (4.07)

RFA：radiofrequency ablation;HLS：high ligation and saphenous vein stripping;OP time：operation time(min);SD：standard deviation;CEAP：clinical,etiological,anatomical,and pathophysiological;

Table 2,Comparison of Primary Efficacy Outcomes (recanalization, Recurrence, and Reintervention Rates)

Item	Total (n = 2740)	RFA (n = 1756)	HLS (n = 984)	P
recanalization	7 (0.26)	7(0.40)	0 (0.00)	0.112
Recurrence	5(0.18)	3(0.17)	2 (0.20)	1.000
Reintervene	71 (2.59)	36 (2.05)	35 (3.56)	0.064

Table 3. The result of postoperative complications

Item	Total (n = 2740)	RFA (n = 1756)	HLS (n = 984)	P
ST	74 (2.70)	54 (3.08)	20 (2.03)	0.106
DVT	4 (0.15)	2 (0.11)	2 (0.20)	0.947
Ecchymosis	602 (21.97)	354 (20.16)	248 (25.20)	**0.002**
Induration	334 (12.19)	302 (17.20)	32 (3.25)	**<.001**
Numbness	166 (6.06)	58 (3.30)	108 (10.98)	**<.001**
Pain	608 (22.19)	358 (20.39)	250 (25.41)	**0.002**
Edema	408 (14.89)	260 (14.81)	148 (15.04)	0.869
hyperpigmentation	54 (1.97)	46 (2.62)	8 (0.81)	**0.001**

ST: superficial thrombophlebitis；DVT: deep vein thrombosis；Recurrence：symptomatic recurrence；
Reintervene：reintervention with foam sclerotherapy

47 **Table 4**,The QoL was measured by the Aberdeen varicose vein questionnaire
48 (AVVQ) (a) and chronic venous insufficiency quality of life questionnaire (CIVIQ 14)
49 (b) scores for patients treated with the RFA or HLS procedure. Compared with the
50 baseline QoL scores, the postprocedure scores were improved following both
51 procedures ($p < 0.05$). The venous clinical severity score (VCSS) (c) was lower
52 postprocedure than at baseline ($p < 0.05$).

Questionnaire	Date	RFA	HLS	P
VCSS	Baseline	6.53±2.64	6.44±3.60	0.458
	1st month	4.44±1.48	4.53±1.57	0.126
	6th month	2.04±1.09	2.03±1.21	0.718
	12th month	0.96±0.72	0.97±1.12	0.671
CIVIQ-14	Baseline	20.33±6.33	19.60±10.50	**0.047**
	1st month	8.88±4.27	9.64±6.08	**＜.001**
	6th month	3.21±2.20	3.18±2.73	0.743
	12th month	1.51±1.13	1.53±1.08	0.622
AVVQ	Baseline	5.89±3.53	5.75±3.03	0.324
	1st month	3.95±1.26	4.19±2.04	**0.001**
	6th month	1.95±1.11	1.94±1.18	0.780
	12th month	0.92±0.77	0.96±0.96	0.259

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