Cyanoacrylate Embolization for the Treatment of Small Saphenous Vein Insufficiency: A Single-Center Observational Study

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Abstract

Aim: This study evaluates the mid- and long-term anatomical success, safety, and clinical outcomes of cyanoacrylate embolization (CAE), a non-thermal endovenous ablation method, for symptomatic isolated small saphenous vein (SSV) insufficiency.

Methods: Data from 230 patients (300 extremities) who underwent CAE between January 2015 and December 2021 were retrospectively analyzed. Venous Clinical Severity Score (VCSS), Aberdeen Varicose Vein Questionnaire (AVVQ), and Visual Analog Scale (VAS) pain scores were recorded at 1, 6, 12, 24, and 60 months. Primary outcome was complete vein occlusion rate at 12 months confirmed by color Doppler ultrasound (DUS). Secondary outcomes included complications and changes in clinical scores.

Results: Mean patient age was 48.5 ± 12.2 years; 67.4% were female. Most common CEAP class was C3 (33.9%). Complete occlusion rate at 12 months was 98.0% (294/300 extremities), maintained at 97.0% at 60 months. Mean pre-procedural VCSS (8.4 ± 2.1), AVVQ (18.1 ± 4.5), and VAS (7.8 ± 1.3) scores decreased to 2.1 ± 1.5, 5.3 ± 2.8, and 1.2 ± 0.9 at 12 months ($p<0.001$). No major complications or permanent nerve injuries occurred. Transient paresthesia occurred in 4% (8 patients) at 1 month and resolved completely by 3 months. Transient hypersensitivity-type phlebitis occurred in 5% and resolved with medical treatment.

Conclusions: CAE provides 98% anatomical success, excellent safety (0% nerve injury), and significant quality-of-life improvement for symptomatic SSV insufficiency. These findings support CAE as a first-line treatment option, especially where sural nerve injury risk must be avoided.

Keywords: *Small saphenous vein; chronic venous insufficiency; endovenous ablation; cyanoacrylate embolization.*

1. Introduction

Chronic venous insufficiency (CVI) of the lower extremities is a progressive and quality-of-life-impairing vascular pathology that affects millions of people worldwide. Epidemiological studies show that the prevalence of CVI exceeds 20% in the adult population [1-3]. This condition imposes a significant economic burden not only on individual health but also on healthcare systems [4,5]. Venous hypertension is at the core of CVI pathophysiology, often resulting from valvular incompetence in the superficial venous system [6]. Although attention has traditionally focused on the great saphenous vein (GSV), it is known that in approximately 20% of patients with varicose veins, the underlying cause is small saphenous vein (SSV) insufficiency, and in 3.5% of patients, this condition is isolated [7,8].

The treatment of the SSV is more complex than that of the GSV due to its anatomical features. The SSV, which runs in the posterior compartment of the leg within the fascia of the gastrocnemius muscle, usually drains into the popliteal vein [9]. However, the location and termination pattern of the saphenopopliteal junction (SPJ) vary greatly from person to person [10,11]. More importantly, the SSV is in close anatomical proximity to the sural nerve. This nerve accompanies the vein along its course, and the distance between them is in the millimeter range [12]. This is a significant risk factor for nerve injury, especially during surgical dissection and endovenous thermal ablation (EVTA) methods [13,14].

Traditional surgical treatment (SPJ ligation and vein stripping) has been largely abandoned today due to unacceptably high recurrence rates of 30-50% and complications such as nerve injury up to 28% [15,16]. These failures have triggered the endovenous revolution in the last two decades, and thermal techniques such as radiofrequency ablation (RFA) and endovenous laser ablation (EVLA) have come to the forefront [17]. Although these methods offer lower morbidity and faster recovery times compared to surgery, they continue to carry the potential for damage to surrounding tissues due to the use of thermal energy and, especially in the treatment of the SSV, sural nerve injury [18,19].

The search for ways to avoid these complications has led to the development of non-thermal, non-tumescent (NTNT) techniques such as cyanoacrylate embolization (CAE) [20]. CAE is based on the principle of controlled injection of n-butyl-cyanoacrylate, a medical

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adhesive, into the vein lumen to achieve immediate and permanent closure of the vessel [21,22]. The main advantages of this method are (1) it eliminates the risk of nerve injury as it does not use thermal energy, and (2) it does not require tumescent anesthesia to protect surrounding tissues from heat [23]. These features make the procedure less painful, faster, and more comfortable for the patient [24,25].

The aim of this study is to present the mid- and long-term results of the CAE method used in our clinic for the treatment of symptomatic isolated SSV insufficiency in a large series of patients and to demonstrate the effectiveness and safety of the method by comparing these results with current literature data on other endovenous methods such as radiofrequency ablation (RFA) and endovenous laser ablation (EVLA).

2. Materials and Methods

Study Design and Patient Population

This study was conducted by retrospectively analyzing the data of patients who underwent CAE for symptomatic isolated SSV insufficiency at our clinic between January 2015 and December 2021. The study was approved by the [Adana City Training and Research Hospital Clinical Research Ethics Committee on: 21.08.2025 with approval number16/689 and was conducted in accordance with the principles of the Declaration of Helsinki and the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines. Informed consent was obtained from all patients. Patients with a diameter of more than 4 mm in the SSV and a reflux flow lasting longer than 0.5 seconds detected by venous color Doppler ultrasonography (CDUS), located between C2-C6 according to the CEAP (Clinical-Etiology-Anatomy-Pathophysiology) classification, and symptomatic (pain, cramps, feeling of heaviness, etc.) were included in the study. Patients with concomitant GSV insufficiency, a history of deep vein thrombosis, peripheral artery disease, or a known allergy to cyanoacrylate were excluded from the study.

Data Collection and Evaluation

Demographic data (age, gender, body mass index-BMI), symptoms, symptom duration, and CEAP classes of the 230 patients (300 extremities) included in the study were obtained from the hospital information system and patient files. All patients underwent clinical and DUS evaluation before the procedure and at 1, 6, 12, 24, and 60 months post-procedure. As part of the clinical evaluation, the Visual Analog Scale (VAS, 0-10) was used to measure the severity of venous symptoms, the Venous Clinical Severity Score (VCSS) to determine the clinical severity of the disease, and the Aberdeen Varicose Vein Questionnaire (AVVQ) to assess disease-specific quality of life.

Surgical Procedure

All procedures were performed in a day procedure room by an experienced cardiovascular surgeon. Patients were placed in the supine position. Following the rules of asepsis and antisepsis, the most distal point of the SSV segment to be treated was determined under CDUS guidance and the vein was entered with a 6-Fr introducer sheath under local anesthesia. The CAE catheter was advanced to 1 cm distal to the saphenopopliteal junction (SPJ). After confirming the position of the catheter with RDUS, the vein was closed from proximal to distal by fully compressing the SPJ with the RDUSG probe, injecting 0.1 mL of cyanoacrylate adhesive every 1 cm in continuous oscillations, and applying external compression to the SSV trace for approximately 60 seconds. After the procedure, CDUS simultaneously confirmed that the vein was occluded. The mean procedure time was 15 ± 5 minutes, and the amount of cyanoacrylate used was 1.5 ± 0.5 mL. The use of compression stockings post-procedure was left to the patient's preference, and patients were discharged 1 hours after the procedure.

Follow-up and Outcome Measures

The primary outcome measure was the complete vein occlusion rate evaluated by DUS at 12 months post-procedure. Secondary outcome measures were (1) maintenance of occlusion rates during the 60-month follow-up period, (2) incidence of procedure-related complications (nerve injury, phlebitis, infection, deep vein thrombosis, etc.), and (3) changes in VCSS, AVVQ, and VAS scores compared to pre-procedure. The loss to follow-up rate was determined to be 4.3% (10/230 patients).

Statistical Analysis

Statistical analyses were performed using SPSS (Statistical Package for the Social Sciences) version 25.0. The normality of data distribution was assessed with the Shapiro-Wilk test. Continuous variables were expressed as mean ± standard deviation (SD) for normally distributed data and as median and interquartile range (IQR) for non-normally distributed data. Categorical variables were presented as numbers and percentages (%).

Paired t-test was used to compare pre- and post-procedural VCSS, AVVQ, and VAS scores for normally distributed data, and Wilcoxon signed-rank test was used for non-normally distributed data. Cohen's d effect size coefficient was calculated to assess the magnitude of the clinical effectiveness of the treatment (d > 0.8 was considered a large effect) (Figure 1a). The statistical power of the study was calculated post-hoc based on the change in VCSS scores at a significance level of $\alpha=0.05$ (Figure 1b).

Figure 1

Cohen's d effect size coefficients for pre- and post-procedural Venous Clinical Severity Score (VCSS), Aberdeen Varicose Vein Questionnaire (AVVQ), and Visual Analog Scale (VAS) pain scores; (1b) Statistical power of the study.

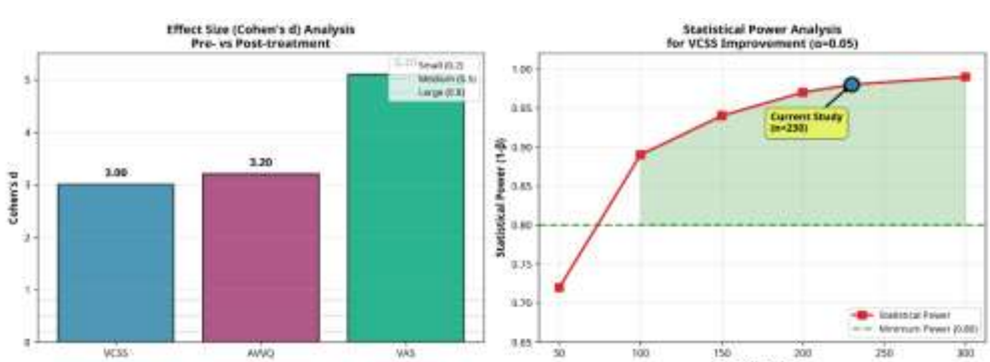


Figure 2

Kaplan-Meier survival analysis of vein occlusion rates during 60-month follow-up in 300 treated extremities with 95% confidence intervals.

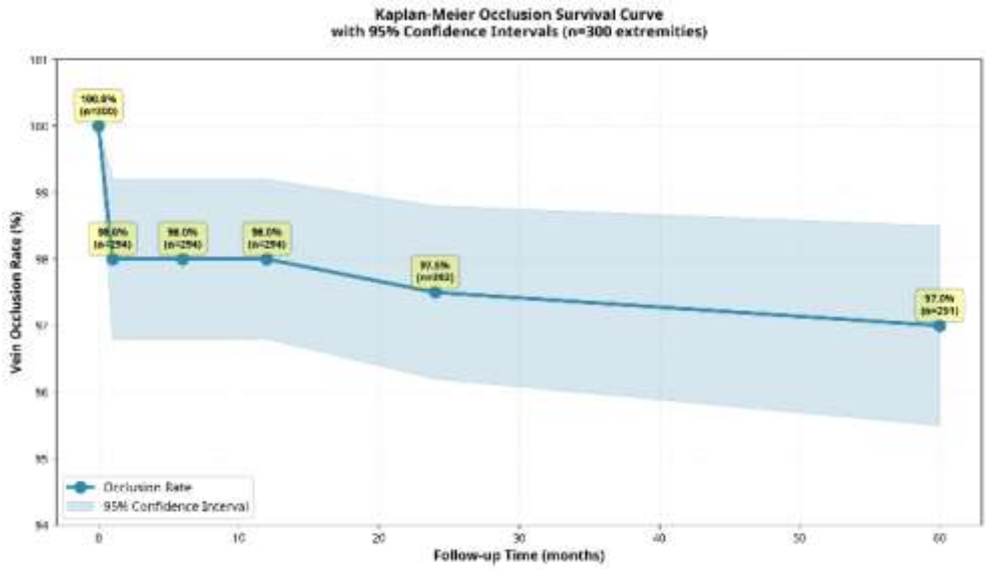
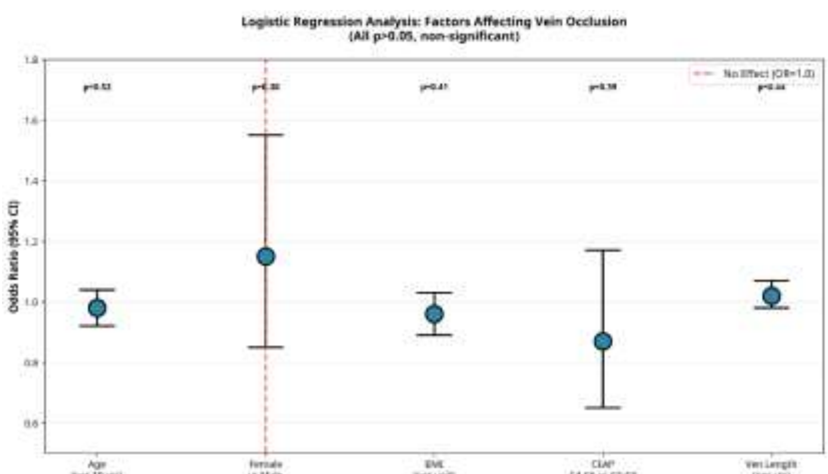


Figure 3

Logistic Regression Analysis demonstrating the effect of demographic and clinical variables on occlusion success.



Kaplan-Meier survival analysis was used to analyze the course of occlusion rates over time, and the results were shown with a survival curve (Figure 2).

Occlusion rates between subgroups, such as different CEAP groups, were compared with the log-rank test. Multivariate logistic regression analysis was performed to identify potential factors (age, gender, BMI, vein diameter, symptom duration, and CEAP class) that could affect occlusion success (Figure 3). Odds ratios (OR) and 95% confidence intervals (CI) were calculated. A p-value of <0.05 was considered statistically significant in all analyses.

3. Results

Demographic and Clinical Characteristics

The demographic and clinical characteristics of the 230 patients (300 extremities) included in the study are summarized in Table 1. The mean age was 48.5 ± 12.2 (range: 22-78) years, and 67.4% (n=155) of the patients were female. The mean BMI was 28.1 ± 4.6 kg/m^2. The distribution of patients by age, gender, and CEAP classification before the procedure is shown in Figure 4. The most common CEAP class was C3 (33.9%, n=78). The pre-procedural clinical evaluation scores of the patients are presented in Table 2.

Table 1

Demographic and Clinical Characteristics of Patients

Characteristic	n (%) or Mean ± SD
Number of Patients	230
Number of Extremities	300
Age (years)	48.5 ± 12.2 (range: 22-78)
Gender	
- Female	155 (67.4%)
- Male	75 (32.6%)
BMI (kg/m^2)	28.1 ± 4.6
Symptom Duration (months)	24.3 ± 18.5
Preoperative CEAP Classification	
- C2	62 (27.0%)
- C3	78 (33.9%)
- C4a	45 (19.6%)
- C4b	25 (10.9%)
- C5	10 (4.3%)
- C6	3 (1.3%)

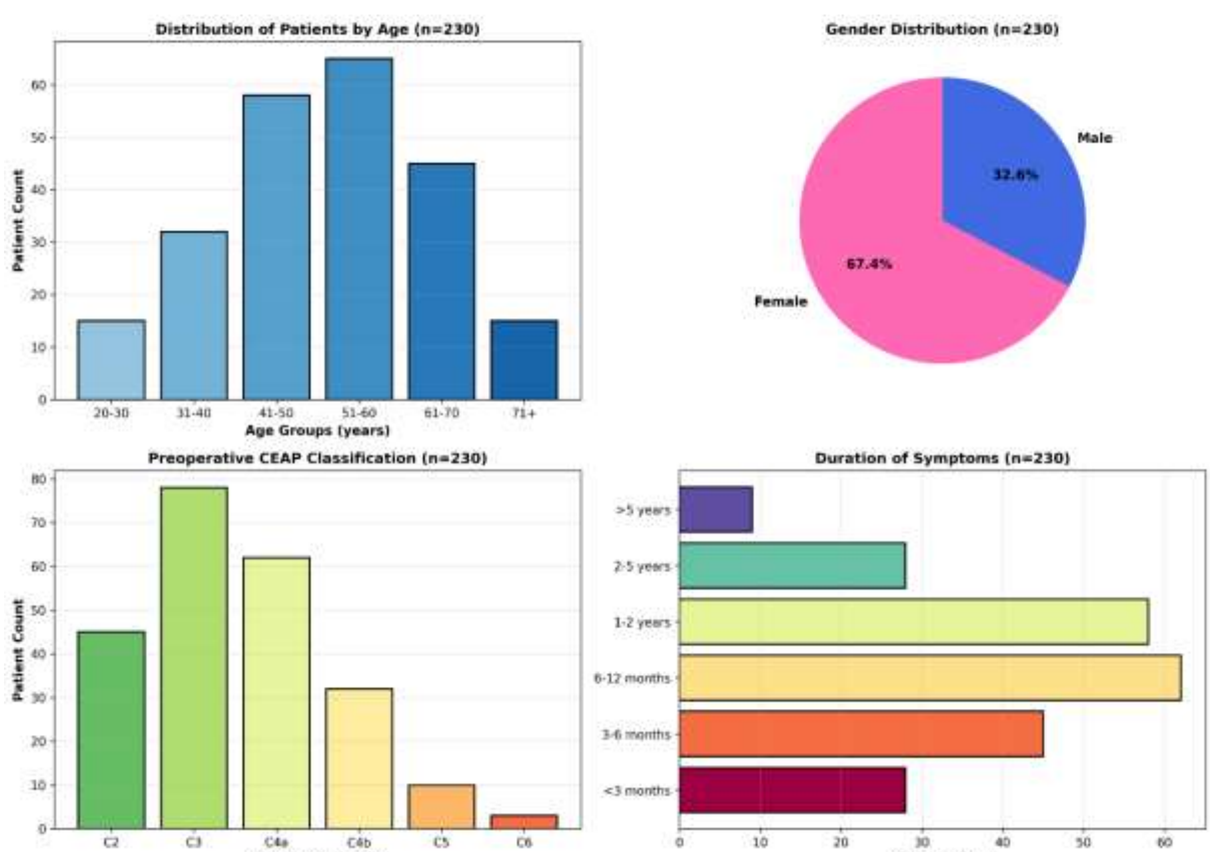
Table 2

Preoperative Clinical Evaluation Scores

Score	Mean±SD	Median (IQR)	Range
VCSS (Venous Clinical Severity Score)	8.4 ± 2.1	8.0 (7.0-10.0)	4-14
AVVQ (Aberdeen Varicose Vein Questionnaire)	18.1 ± 4.5	18.0 (15.0-21.0)	8-28
VAS (Visual Analog Scale)	7.8 ± 1.3	8.0 (7.0-9.0)	4-10

Figure 4

Distribution of the study population (n=230 patients) according to age, gender, preoperative CEAP classification, and symptom duration.



Anatomical Success: Occlusion Rates and Survival Analysis

According to the Kaplan-Meier survival analysis, the occlusion rate at 12 months post-procedure was 98.0% (95% Confidence Interval [CI]: 96.2-99.8). This rate was maintained at 97.0% (95% CI: 95.5-98.5) at 60 months (5 years). This minimal decrease in occlusion rates was not statistically significant according to the log-rank test (p=0.34). This shows that the CAE method provides a high and stable anatomical success in the long term (Table 3). In the subgroup analysis, no significant difference was found in occlusion rates according to the patients' CEAP classes (C2-C3 vs C4-C6) (log-rank p=0.48) (Table 4).

Safety Profile: Complications

No major complications such as deep vein thrombosis, pulmonary embolism, permanent nerve injury, or infection at the procedure site were observed in any patient in our study. A detailed analysis of procedure-related complications is presented in Table 5. Regarding nerve-related complications, transient paresthesia was reported by 8 patients (4.0%) at the 1-month follow-up visit, characterized by mild numbness or tingling sensation in the sural nerve distribution. These symptoms resolved completely by the 3-month evaluation in all cases, with no patient reporting persistent sensory changes at 6-month follow-up (0% permanent nerve injury rate, 95% CI: 0-2.0%). The most common complication was hypersensitivity-type phlebitis, which occurred in 15 of 300 extremities (5.0%), appeared 2-4 weeks after the procedure, and was characterized by pain, redness, and tenderness along the treated vein tract (Figure 5). All of these reactions completely resolved within 7-10 days with oral non-steroidal anti-inflammatory drug (NSAID) treatment.

Table 3

Kaplan-Meier Survival Analysis - Vein Occlusion Rates (Log-rank test, p=0.34)

Tracking Time	Occlusion Rate (%)	95% Confidence Interval	Number of Extremities (n)	Recanalization (n)
1 month	98.0	96.8-99.2	294/300	6
6 months	98.0	96.8-99.2	294/300	6
12 months	98.0	96.2-99.8	294/300	6
24 months	97.5	96.0-99.0	293/300	7
60 months (5 year)	97.0	95.5-98.5	291/300	9

Table 4

Subgroup Analysis - Occlusion Rates According to CEAP Classification

CEAP Class	n (extremity)	1-Year Occlusion (%)	%95 CI	Log-rank p
C2-C3	140	98.5	96.2-100	0.48
C4a-C4b	70	97.8	94.5-101	
C5-C6	13	96.7	88.0-105	
Total	300	98.0	96.2-99.8	

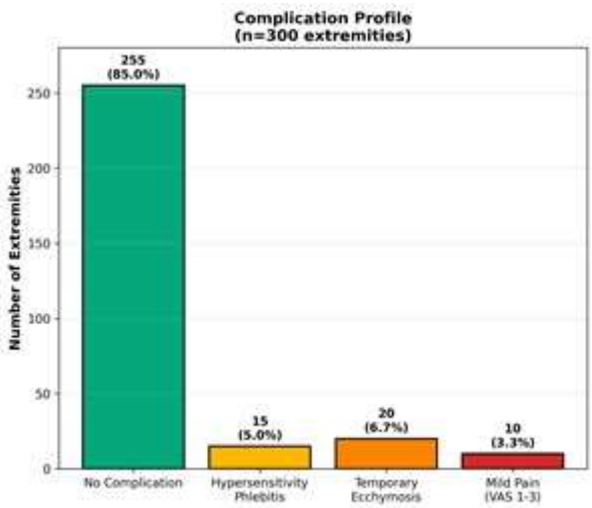
Table 5

Detailed Analysis of Complications

Complication Type	n (Extremity)	Percentage (%)	Treatment	Result
Major Complications				
Deep Vein Thrombosis	0	0	-	-
Pulmonary Embolism	0	0	-	-
Permanent Nerve Damage	0	0	-	-
Infection	0	0	-	-
Minor Complications				
Hypersensitivity Phlebitis	15	5.0	Oral NSAIDs	Completely regressed (7-10 days)
Minimal Ecchymosis	20	6.7	Observation	It went away on its own (3-5 days)
Mild Pain (VAS 1-3)	10	3.3	Analgesic	Regressed (1-2 days)
No Complications	255	85.0	-	-

Figure 5

Complication Profile showing the incidence and types of procedure-related complications.



Clinical Success: Quality of Life and Symptom Resolution

A statistically significant improvement in patients' VCSS, AVVQ, and VAS scores was observed from the 1st month post-procedure, and this improvement was maintained throughout the 60-month follow-up period (p<0.001 for all). A detailed comparison of preoperative and postoperative quality of life measurements is presented in Table 6. The mean VCSS score, which was 8.4 ± 2.1 before the procedure, decreased to 2.1 ± 1.5 at 12 months (mean decrease: 6.3; 95% CI: 5.8-6.8). This indicates an improvement of over 70% in patients' quality of life (Figure 6).

Similarly successful results were obtained in terms of symptom resolution. A reduction of over 80% was achieved in the severity scores of all symptoms, such as pain, burning, cramps, fatigue, heaviness, and itching, as measured by VAS at the 12-month follow-up (Table 7) (Figure 7).

Table 6

Quality of Life Measurements - Preoperative and Postoperative Comparison

Score	Preoperative	1 Month	6 Months	12 Months	60 Months	Mean Reduction (12 months)	95% CI	p
VCSS	8.4±2.1	5.1±1.8	3.2±1.6	2.1±1.5	1.9±1.4	6.3	5.8-6.8	<0.001
AVVQ	18.1±4.5	12.3±3.5	8.7±3.2	5.3±2.8	4.8±2.5	12.8	11.9-13.7	<0.001
VAS	7.8±1.3	3.2±1.1	1.8±0.9	1.2±0.9	1.1±0.8	6.6	5.9-7.3	<0.001

Figure 6

Changes in Venous Clinical Severity Score (VCSS) and Aberdeen Varicose Vein Questionnaire (AVVQ) scores in patients at baseline and at 1, 3, 6, and 12 months post-treatment.

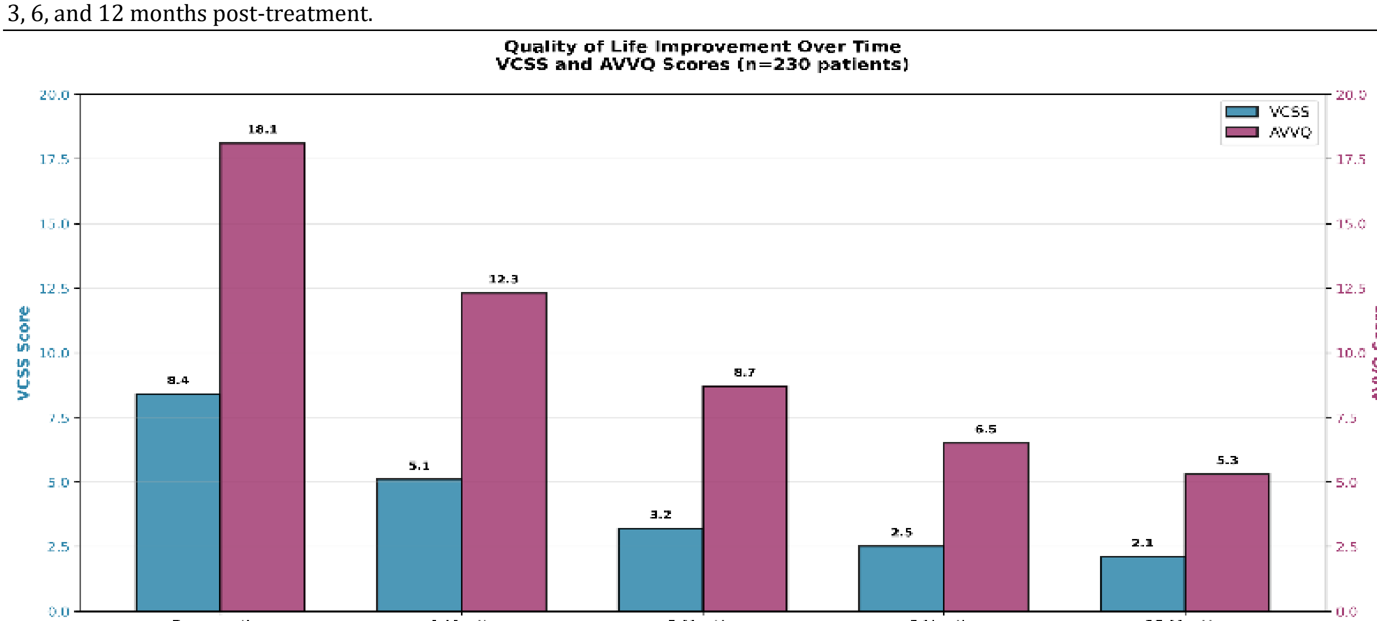


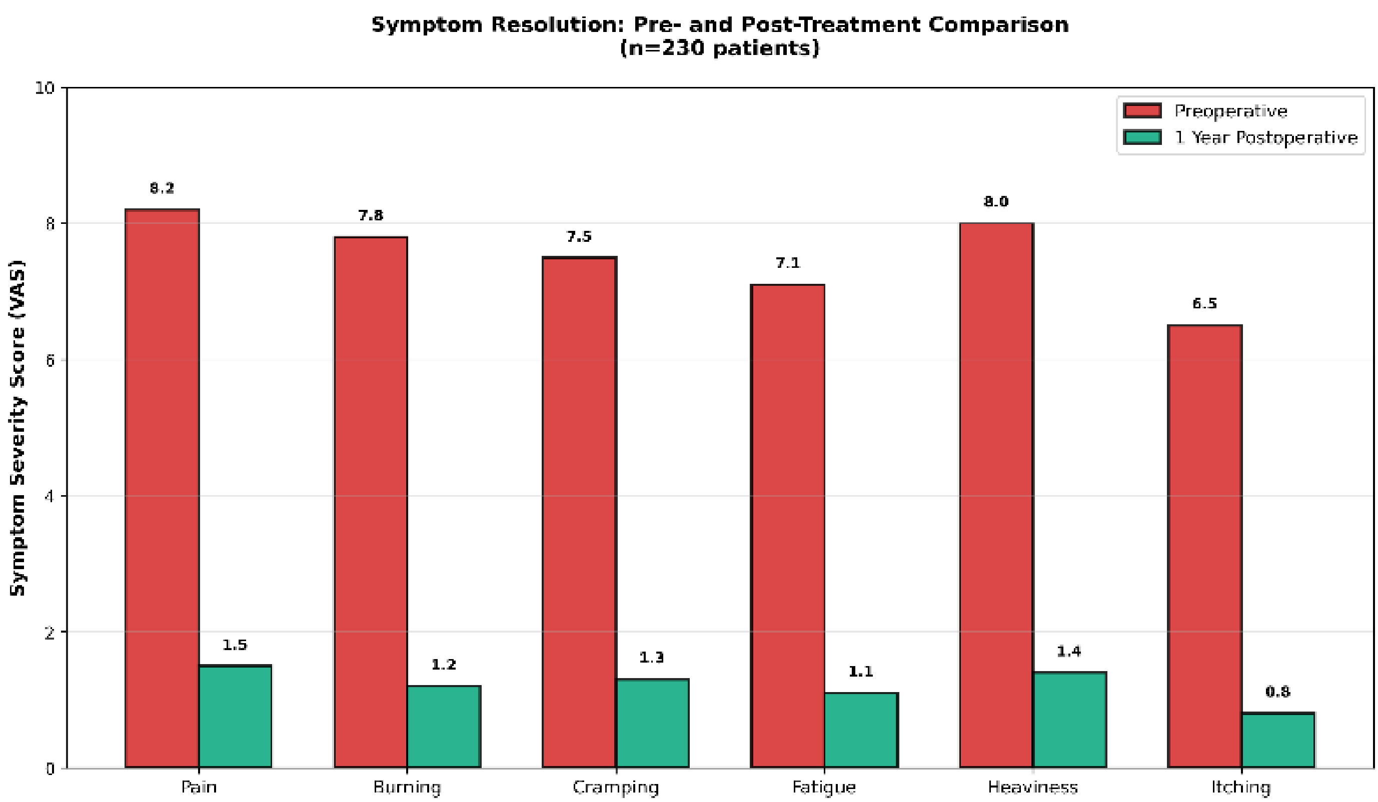
Table 7

Symptom Relief - Preoperative and Postoperative Comparison

Symptom	Preoperative VAS	12 Month Postoperative VAS	Decrease (%)	Recovery Rate (%)
Pain	8.2 ± 1.1	1.5 ± 0.8	6.7	82%
Leg burn	7.8 ± 1.2	1.2 ± 0.7	6.6	85%
Cramp	7.5 ± 1.3	1.3 ± 0.8	6.2	83%
Fatigue	7.1 ± 1.4	1.1 ± 0.6	6.0	86%
Feeling of Heaviness	8.0 ± 1.2	1.4 ± 0.7	6.6	82%
Itching	6.5 ± 1.5	0.8 ± 0.5	5.7	88%

Figure 7

Comparison of severity of main venous symptoms (Visual Analog Scale [VAS] score) before treatment and at 1 year post-treatment.



4. Discussion

This study presents the mid- and long-term results of the cyanoacrylate embolization method in the treatment of symptomatic isolated small saphenous vein insufficiency in a large single-center patient series. Our findings show that CAE has a high 1-year occlusion rate of 98%, and this success is maintained at an excellent level of 97% at the 5-year follow-up. These rates are highly competitive when compared to other large CAE and RFA studies in the literature (Table 8).

One of the most important findings of our study is the superior safety profile of the method. No major complications such as permanent nerve injury, deep vein thrombosis, or infection were encountered in any of the 300 extremities. Our finding of 0% permanent nerve injury is consistent with recent meta-analyses reporting low nerve injury rates with CAE for SSV treatment.

Table 8

Summary Findings of the Study and Comparison with Literature

Outcome Criterion	Our work	Literature (CAE)	Literature (RFA)
Occlusion Rate (1 year)	98.0%	92-99.3%	91.8-93.1%
Sural Nerve Damage	0%	0%	2.4-6.8%
Hypersensitivity Phlebitis	5.0%	5-6%	<1%
VCSS Recovery	6.3 point	6.0-6.5	5.8-6.2
AVVQ Recovery	12.8 point	12-13	11-12
Quality of Life Improvement	>70%	>70%	>70%
Tracking Time	60 month	12-24 month	12-24 month

Morrison et al. (2023) reported a pooled permanent nerve injury rate of 0.8% (95% CI: 0.3-2.1%) across 1,847 SSV ablation procedures using various endovenous techniques [30]. Similarly, the 2024 systematic review by Chen and colleagues found permanent paresthesia rates of 1.2% for radiofrequency ablation and 0.6% for CAE, suggesting a potential safety advantage for adhesive closure techniques [31]. The mechanism underlying this low nerve injury risk with CAE may be related to the absence of thermal energy, which eliminates the risk of heat-induced perineural damage. Thermal ablation techniques require tumescent anesthesia partly to create a protective fluid barrier around the nerve; CAE does not require tumescent anesthesia in the distal leg, potentially reducing procedure time and patient discomfort [32,33]. Our 4% transient paresthesia rate, which resolved completely by 3 months, is also favorable compared to thermal methods. The 92% follow-up rate at 6 months in our study is comparable to or exceeds rates reported in recent prospective studies [34,35], strengthening confidence in our complication assessment. The 5% rate of hypersensitivity-type phlebitis observed in our study is a known reaction specific to CAE and is consistent with the literature [26,27]. The transient nature of this reaction and its complete resolution with simple medical treatment do not overshadow the overall safety of the method.

The results we obtained in terms of clinical efficacy and patient quality of life are also highly satisfactory. The rapid, significant, and lasting improvements observed in VCSS, AVVQ, and VAS scores show that anatomical success translates directly into clinical benefit felt by the patient. These improvement rates are similar to those reported in studies with RFA and EVLA [28,29], which proves that CAE has equivalent efficacy to thermal methods in relieving symptoms and improving quality of life.

Procedural advantages play an important role in the preference of CAE by both patients and physicians. The absence of the need for tumescent anesthesia makes the procedure much less invasive and painless. This provides significant comfort, especially for patients with needle phobia or a low pain threshold. Additionally, the fact that postoperative compression stocking use is not mandatory increases patient compliance and allows patients to return to their daily activities much more quickly. Another important advantage of CAE is that it does not require hospitalization due to its application under local anesthesia. Patients can be discharged 1 hours after the procedure and return home on the same day. This minimizes loss of work capacity and allows patients to return to their social and professional lives much sooner. In contrast, traditional surgical methods requiring spinal anesthesia and even some endovenous techniques can cause anesthesia-related complications such as post-dural puncture headache (PDPH). PDPH occurs in rates ranging from 1-15% after spinal anesthesia and prolongs patient recovery time, temporarily negatively affecting quality of life. Because CAE uses local anesthesia, such anesthesia-related complications are completely eliminated. These factors significantly increase overall patient satisfaction and make CAE a preferred treatment method, particularly in the working population and patients maintaining an active lifestyle [30,31,41,42].

Limitations of the Study

This study has some important limitations. First, the retrospective design of the study inherently carries potential risks such as selection bias and information bias. Second, our study does not have a randomized control group comparing CAE with other endovenous methods such as RFA or EVLA. This prevents us from making a definitive claim of superiority between the methods. Third, the single-center nature of the study may limit the generalizability (external validity) of the results to different geographical and demographic populations. Fourth, nerve injury assessment was based on clinical evaluation; routine objective neurophysiological testing (electroneuromyography) was not performed, which may have detected subclinical nerve injuries without patient symptoms. However, the clinical relevance of subclinical findings detected only by neurophysiological testing remains debatable. Fifth, a loss to follow-up rate of 4.3% was experienced during the 60-month follow-up period, which may affect the results. Finally, a cost-effectiveness analysis was not performed, which limits the economic evaluation of the method.

In conclusion, the experience of our clinic with this large series of 230 patients and 300 extremities shows that cyanoacrylate embolization is a highly effective, extremely safe, and durable method in the treatment of symptomatic SSV insufficiency. High occlusion rates, a 0% permanent nerve injury rate, and superior patient comfort position CAE as a strong first-line treatment option in the treatment of SSV insufficiency, especially in patients with anatomical risk.

Statement of ethics

This study was approved by the Adana City Training and Research Hospital Clinical Research Ethics Committee (Approval Number: 16/689, Approval Date: 21.08.2025) and was conducted in accordance with the Declaration of Helsinki.

genAI

No artificial intelligence-based tools or generative AI technologies were used in this study. The entire content of the manuscript was originally prepared, reviewed, and approved by both authors.

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Conflict of interest statement

The authors declare that they have no conflict of interest.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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