



Stump Length Changes after Endovenous Cyanoacrylate Closure or Radiofrequency Ablation for Saphenous Vein Incompetence

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Purpose: The aim of this study was to analyze changes in stump length over time in patients with saphenous vein incompetence treated with cyanoacrylate closure (CAC) or radiofrequency ablation (RFA).

Materials and Methods: We retrospectively analyzed data collected from patients with saphenous vein incompetence who underwent either CAC or RFA at Seoul National University Hospital between November 2015 and December 2018. The stump lengths were measured using duplex ultrasonography (DUS) within 1 month and 6 months after treatment. The Venous Clinical Severity Score (VCSS) and Aberdeen Varicose Vein Questionnaire (AVVQ) score were used to assess clinical outcomes.

Results: A total of 97 veins (64 great saphenous veins and 33 small saphenous veins) were analyzed. The stump length was not significantly different between the two groups at <1 month ($P=0.311$). However, the stump length in the CAC group was significantly longer than that in the RFA group at 6 months ($P=0.004$). At 6 months, the mean change in stump length was 1.41 ± 2.28 cm in the CAC group and 0.51 ± 0.54 cm in the RFA group ($P=0.006$). The VCSSs and AVVQ scores significantly improved after both procedures but were not significantly different between the two groups.

Conclusion: DUS at 6 months after treatment showed that the stump length in the CAC group increased more than that in the RFA group. No other factors affected the changes in stump length.

Key Words: Radiofrequency ablation, Glues, Varicose veins, Recurrence, Duplex ultrasonography

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INTRODUCTION

The treatment of saphenous vein incompetence has become less invasive over time. The paradigm is shifting from surgical treatment (high ligation and stripping of the saphenous vein) to endovenous treatment (EVT). In particular, EVT is divided into the following two categories: (1) thermal ablation such as radiofrequency ablation (RFA) and

endovenous laser ablation and (2) nonthermal nontumescent ablation such as mechanochemical endovenous ablation and endovenous glue ablation.

Endovenous glue ablation or cyanoacrylate closure (CAC) has several advantages. It eliminates the need for tumescent anesthesia, resulting in less posttreatment pain and bruising in patients. It also eliminates the need for postoperative compression stockings because of the chemical bonding of

the vein walls to each other. Furthermore, there is no risk of sensory nerve damage owing to the nonthermal nature of the technique.

Previous studies have demonstrated that the short-term recurrence rate after CAC is noninferior to that after RFA [1-6]. However, few studies have been published about the long-term recurrence rate after CAC because of the short follow-up period from the initial clinical application of the procedure. Although the long-term outcomes of these treatments can be predicted by assessing the changes in stump length, the literature is scarce.

Therefore, in this study, we aimed to analyze the changes in stump length over time using duplex ultrasonography (DUS) in patients with saphenous vein incompetence treated with CAC or RFA.

MATERIALS AND METHODS

We prospectively collected and retrospectively analyzed the data of patients with saphenous vein incompetence who underwent either CAC or RFA at a single center between November 2015 and December 2018. Among the patients who underwent CAC or RFA during this period, all of those who underwent DUS at <1 month and 6 months after treatment were included. The first CAC in this study was performed in November 2017. This study was approved by the Institutional Review Board of Seoul National University Hospital (approval no. 2008-098-1149), and informed consent was waived because of the retrospective nature of the study and because the analysis used anonymous clinical data.

1) Devices and procedures

All patients underwent the procedure under local anesthesia. The CAC group was treated using the VenaSeal

closure system (Medtronic, Minneapolis, MN, USA). The VenaSeal catheter was positioned 5 cm caudally to the saphenofemoral junction (SFJ) or saphenopopliteal junction (SPJ). In the CAC group, we delivered 0.1 mL cyanoacrylate with proximal saphenous vein compression using an ultrasound probe. The catheter was pulled back about 1 cm, and 0.1 mL cyanoacrylate was delivered again followed by saphenous vein compression for 3 min. Cyanoacrylate (0.1 mL) was delivered once at every 3-cm interval with saphenous vein compression for 30 s.

The RFA group was treated with VNUS ClosureFast (Medtronic). The RFA catheter was positioned 2.0 to 2.5 cm caudally to the SFJ or SPJ. A tumescent solution was injected along the saphenous vein with a 22-gauge spinal needle under ultrasonographic guidance. The tumescent solution consisted of 500 mL of normal saline, 40 mL of 2% lidocaine, and 5 mL of 8.4% sodium bicarbonate. Ablation was performed twice in the first segment and once every 6.5-cm thereafter. After both procedures, the surgeon confirmed the closure of the treated vein using DUS. In the RFA group, compressive stockings were applied for 1 to 2 weeks after the procedure.

2) Follow-up and outcomes

Saphenous vein incompetence was diagnosed using DUS, and pathologic reflux of the saphenous vein was defined as a retrograde flow of >0.5 second. The great saphenous vein (GSV) and small saphenous vein (SSV) diameters were measured at a distance of 2 cm from the SFJ or SPJ. The stump length, defined as the distance from the SFJ/SPJ to the obliterans, was measured using DUS at <1 month and 6 months after treatment. Anatomical recurrence or recanalization was defined as a stump length of >5 cm (Fig. 1).

Clinical outcomes were assessed using the Venous Clinical Severity Score (VCSS) and Aberdeen Varicose Vein Ques-

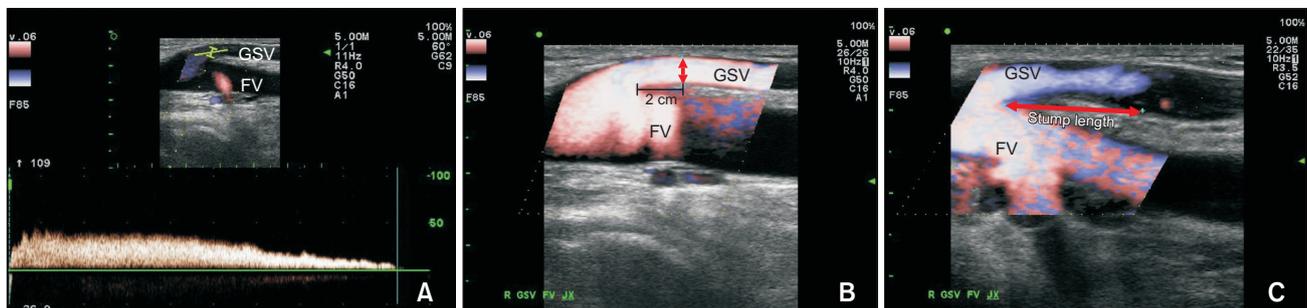


Fig. 1. (A) Duplex ultrasonographic image of saphenous vein incompetence with pathologic reflux defined as a retrograde flow of >0.5 second. (B) The great saphenous vein (GSV) and small saphenous vein diameters were measured at a distance of 2 cm from the saphenofemoral/saphenopopliteal junction. (C) The stump length after the procedure was measured from the junction to the obliterans. FV, femoral vein.

tionnaire (AVVQ) score. Interviews were conducted before treatment and at 1, 3, 6, and 12 months after treatment. In addition, complications such as endovenous glue-induced thrombosis (EGIT), endovenous heat-induced thrombosis (EHIT), ecchymosis, phlebitis, paresthesia, infections, and skin burns were investigated.

3) Statistical analysis

Continuous data are expressed as mean±standard deviation or mean (range). Categorical data are expressed as count (percentage). The differences in stump length between the two groups were analyzed using an independent t-test. Correlation analysis (Spearman's rho) was performed to evaluate the association between stump length and various factors. Statistical significance was set at $P < 0.05$. Statistical analyses were performed using SPSS for Windows (version 21.0; IBM Corp., Armonk, NY, USA).

RESULTS

Seventy-one patients with saphenous vein incompetence

Table 1. Baseline characteristics of patients (n=71)

Characteristic	CAC (n=38)	RFA (n=33)	P-value
Age (y)	61.9 (19-86)	56.9 (25-75)	0.083
Sex			0.776
Male	8 (21.1)	6 (18.2)	
Female	30 (78.9)	27 (81.8)	
Body mass index (kg/m ²)	24.6 (17.2-32.0)	24.0 (18.2-30.9)	0.427
Primary symptom			0.041
Pain	6 (15.8)	0 (0.0)	
Heaviness	4 (10.5)	9 (27.3)	
Swelling	6 (15.8)	10 (30.3)	
Numbness	1 (2.6)	1 (3.0)	
Cramps	12 (31.6)	5 (15.2)	
Engorged veins	9 (23.7)	8 (24.2)	
CEAP classification			0.427
C2	28 (73.7)	21 (63.6)	
C3	10 (26.3)	11 (33.3)	
C4	0 (0.0)	1 (3.0)	
VCSS	4.4±2.7	3.9±2.1	0.403
AVVQ score	7.0±5.3	7.7±5.4	0.566

Values are presented as mean (range), number (%), or mean±standard deviation.

CAC, cyanoacrylate closure; RFA, radiofrequency ablation; CEAP, clinical-etiological-anatomical-pathophysiologic; VCSS, Venous Clinical Severity Score; AVVQ, Aberdeen Varicose Vein Questionnaire.

underwent either CAC (n=38) or RFA (n=33). The mean patient age was 61.9 and 56.9 years in the CAC and RFA groups, respectively ($P=0.083$). The CAC and RFA groups included 30 (78.9%) and 27 (81.8%) females, respectively. The mean body mass index (BMI) was 24.6 and 24.0 kg/m² in the CAC and RFA groups, respectively ($P=0.427$). In the clinical-etiological-anatomical-pathophysiologic classification, most patients in both groups were classified as C2 and one patient in the RFA group was classified as C4. Before the CAC or RFA procedure, the mean VCSS and AVVQ score, which were similarly distributed, were not statistically different between the two groups (VCSS: 4.4 in CAC vs. 3.9 in RFA, $P=0.403$; AVVQ score: 7.0 in CAC vs. 7.7 in RFA, $P=0.566$; Table 1).

A total of 97 veins (64 GSVs and 33 SSVs) were analyzed in this study. The mean GSV diameter was 0.55 and 0.59 cm ($P=0.419$) and the mean SSV diameter was 0.42 and 0.54 cm in the CAC and RFA groups, respectively ($P=0.045$; Table 2).

1) Changes in stump length

The mean stump length at <1 month was not significantly different between the two treatment groups (CAC: 1.39±1.13 cm, RFA: 1.19±0.74 cm, $P=0.311$). However, the mean stump length in the CAC group was significantly longer than that in the RFA group at 6 months (CAC: 2.80±2.61 cm, RFA: 1.70±0.72 cm, $P=0.004$). The change in stump length was 1.41±2.28 cm in the CAC group, which included five cases with a change of >5 cm, and 0.51±0.54 cm in

Table 2. Duplex ultrasonographic characteristics of veins (n=97)

Characteristic	CAC (n=57)	RFA (n=40)	P-value
Lesion			0.259
GSV	35 (61.4)	29 (72.5)	
SSV	22 (38.6)	11 (27.5)	
Diameter (cm)			
GSV	0.55±0.16	0.59±0.19	0.419
SSV	0.42±0.13	0.54±0.21	0.045
Perforator			0.510
None	51 (89.5)	34 (85.0)	
≥1	6 (10.5)	6 (15.0)	
Reflux duration (sec)			
GSV	4.11±2.23	4.03±1.80	0.874
SSV	6.46±3.08	5.41±2.64	0.342

Values are presented as number (%) or mean±standard deviation. CAC, cyanoacrylate closure; RFA, radiofrequency ablation; GSV, great saphenous vein; SSV, small saphenous vein.

the RFA group, which had a maximum increase of 1.87 cm ($P=0.006$; Fig. 2).

2) Association between stump length and vein diameter

No correlation was observed between the stump length and vein diameter at <1 month (GSV: $\rho=0.176$, $P=0.182$; SSV: $\rho=-0.267$, $P=0.133$) and 6 months (GSV: $\rho=0.252$, $P=0.054$; SSV: $\rho=-0.284$, $P=0.109$) or in the change in stump length and vein diameter (GSV: $\rho=0.142$, $P=0.282$; SSV: $\rho=-0.153$, $P=0.396$; Fig. 3).

3) Recanalization

The recanalization-free rate was 94.7% at <1 month and 77.2% at 6 months in the CAC group. However, recanaliza-

tion was not observed in the RFA group. Of the 13 patients with recanalization in the CAC group, 5 patients had an increase in stump length of >5 cm between <1 month and 6 months (one GSV, four SSVs; one male, four females; mean age, 59.8 years; mean BMI, 25.74 kg/m²; mean vein diameter, 0.45 cm).

4) Clinical outcomes

The VCSSs and AVVQ scores significantly improved after both procedures, with no significant differences between the two groups. However, the scores in the RFA group were significantly higher than those in the CAC group at <1 month, which was most likely owing to the use of compression stockings for the first few weeks after the RFA procedure (Fig. 4).

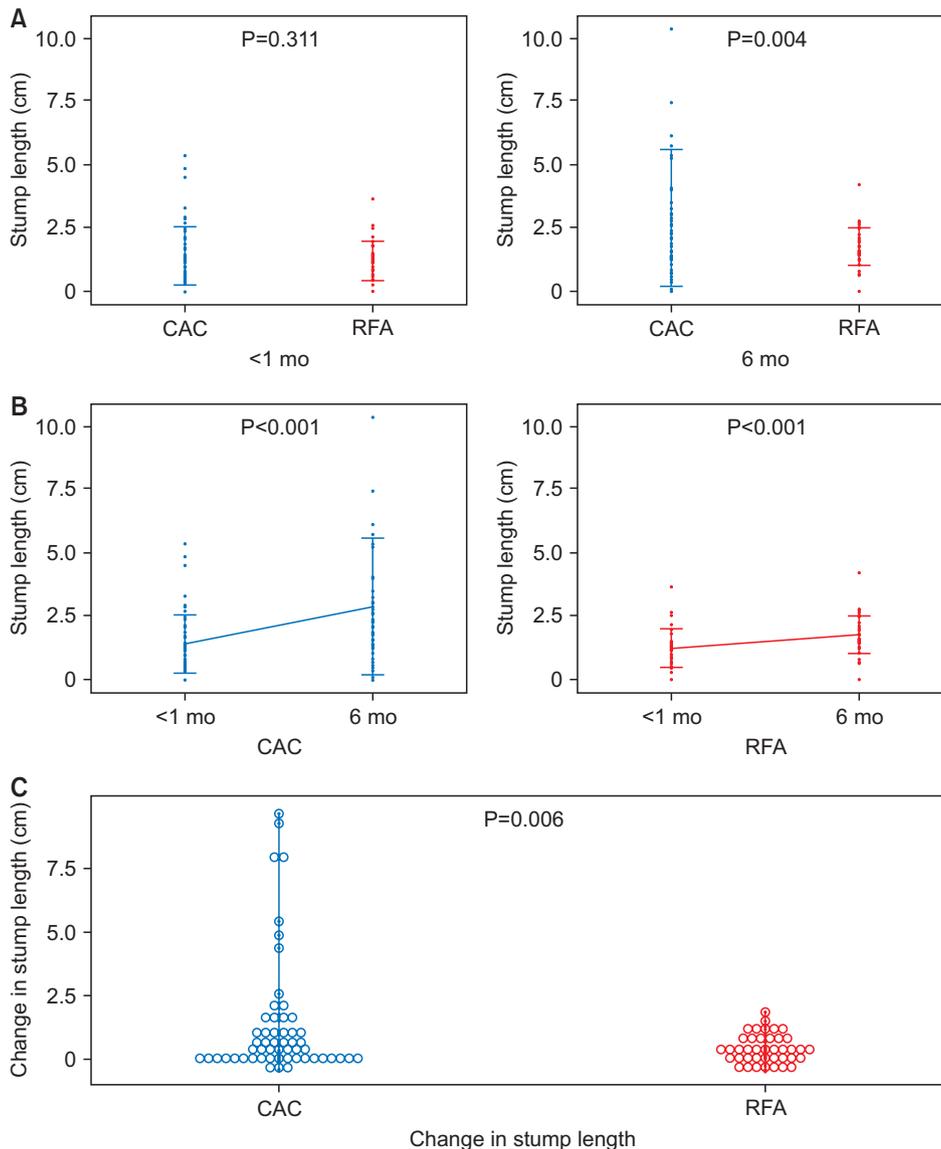


Fig. 2. Mean \pm standard deviation of stump length. (A) The stump length at <1 month was not significantly different between the two treatment groups. However, the stump length at 6 months was significantly longer in the cyanoacrylate closure (CAC) group than in the radiofrequency ablation (RFA) group. (B) The changes in stump length at <1 month and 6 months were significant in both groups. (C) The distribution of changes in stump length was wider in the CAC group.

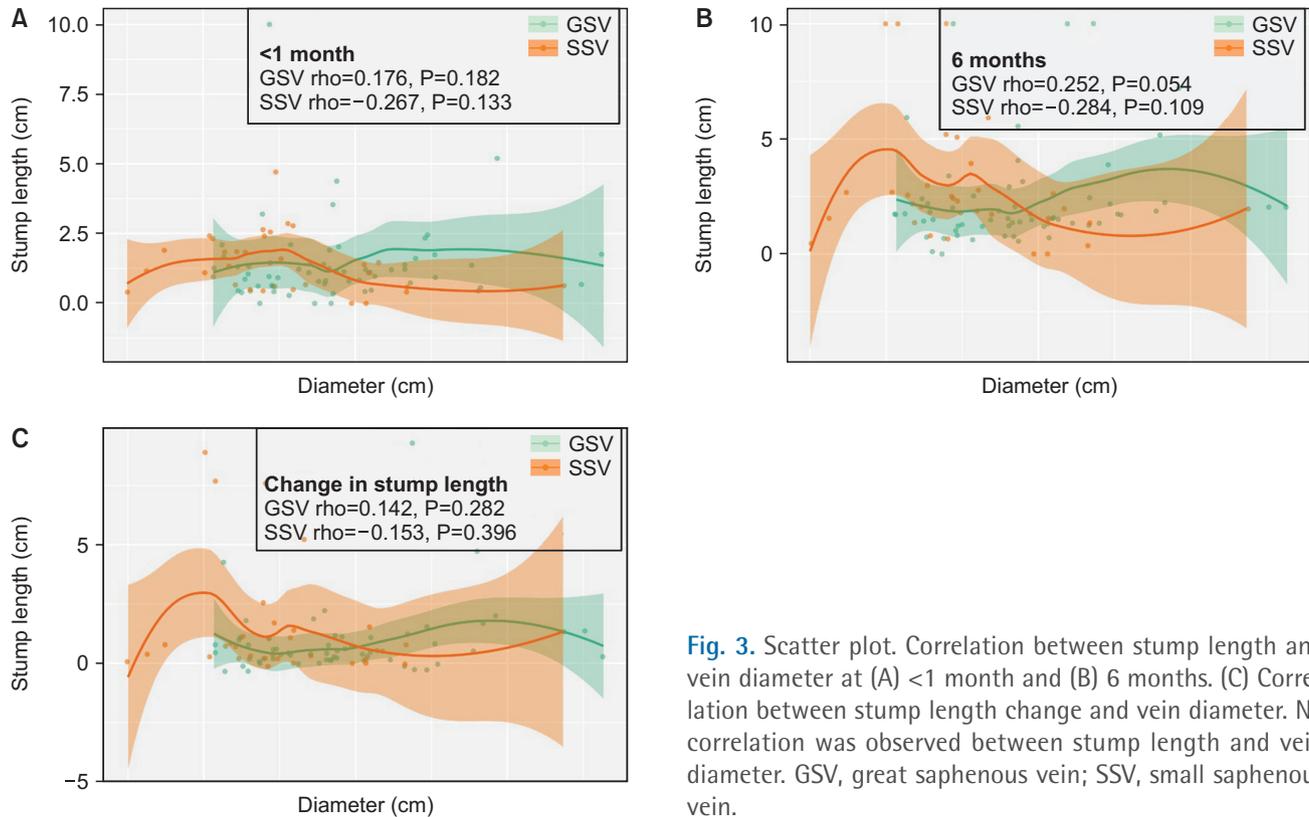


Fig. 3. Scatter plot. Correlation between stump length and vein diameter at (A) <1 month and (B) 6 months. (C) Correlation between stump length change and vein diameter. No correlation was observed between stump length and vein diameter. GSV, great saphenous vein; SSV, small saphenous vein.

Ecchymosis was observed in two patients in the RFA group and in six patients in the CAC group. A phlebitis-like allergic reaction, which was mild and self-limiting, developed in four patients in the CAC group. Three patients had grade 2 EGIT and were conservatively treated. At the 6-month follow-up, a reduced extent of thrombosis was observed on DUS. No additional procedures were performed in these patients.

DISCUSSION

The conventional surgical treatment of varicose veins (high ligation and stripping) is now being replaced by EVT [7]. Previous studies found no significant difference in recurrence rate between surgery and EVT [8], although the primary cause of recurrence was reported to be different between the two groups [9,10]. The most commonly reported cause of recurrence was neovascularization after surgery and recanalization after EVT [9,11]. An increase in the stump length after EVT increases the potential for recanalization through the collateral veins around the SFJ [12]. Therefore, we investigated whether a temporal change in stump length occurs after EVT for saphenous vein insufficiency, and compared the differences in stump length change, anatomical or clinical outcomes, and recurrence rate between the EVT methods.

According to our data, a greater change in stump length occurred in the CAC group. However, the change in stump length was not related to the vein diameter. A higher rate of anatomical recanalization was observed in the CAC group than in the RFA group. The difference in the change in stump length between the CAC and RFA groups was probably due to different mechanisms of vein occlusion. Radio-frequency causes thermal destruction and vein shrinkage with subsequent fibrotic vein occlusion [13]. However, cyanoacrylate is a medical-grade adhesive that rapidly polymerizes once it contacts blood [14]. When cyanoacrylate is polymerized, a glue cast is formed, which disrupts the intima of the vein and produces an inflammatory response, ultimately leading to fibrosis and closure of the vein [15]. In a previous histopathologic analysis conducted 5.5 years after CAC treatment, CAC was considered to cause a type of foreign body reaction [16]. The saphenous vein was occluded with collagenized mature fibrous tissue and polymer remnants, which were encapsulated by multinucleated giant cells [16]. McGuinness et al. [17] suggested that the cast adhesive may exhibit gradual absorption over time.

Some researchers have hypothesized that there may be a correlation between stump length and vein diameter. Kim et al. [18] showed a significant correlation between the preoperative vein diameter (distance of 5 cm from the SFJ) and stump length on postoperative day 0 ($\rho=0.528$, $P=0.005$).

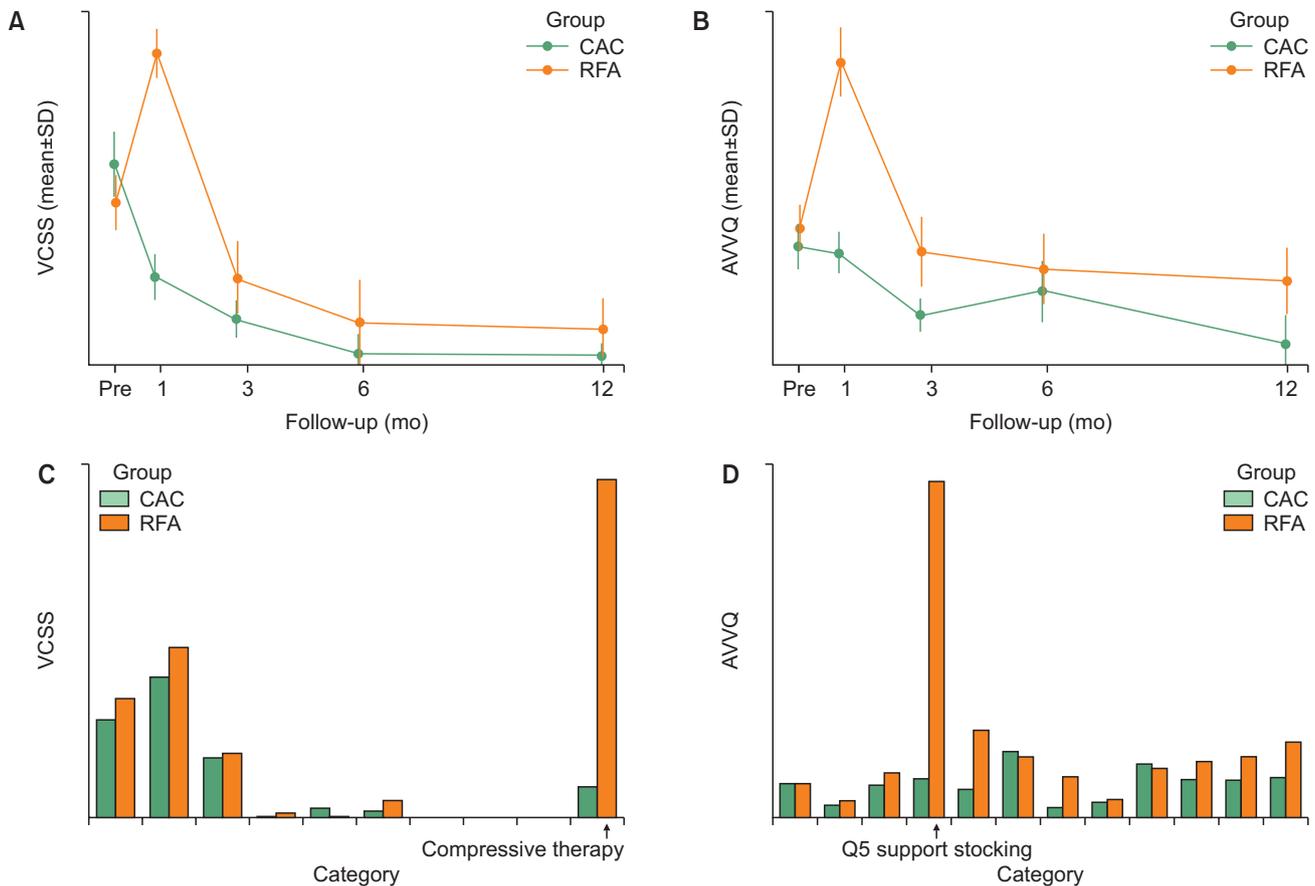


Fig. 4. Venous Clinical Severity Scores (VCSSs) and Aberdeen Varicose Vein Questionnaire (AVVQ) scores at follow-up in the cyanoacrylate closure (CAC) and radiofrequency ablation (RFA) groups. The (A) VCSSs and (B) AVVQ scores significantly improved after both procedures without any significant differences between the two groups. However, the RFA group showed significantly higher (C) VCSSs and (D) AVVQ scores than the CAC group at <1 month.

but not on postoperative day 7 ($\rho=0.430$, $P=0.430$). In another study, an inverse relationship was reported between the immediate postoperative stump length and the vein diameter (distance of 3 cm from the SFJ) ($\rho=-0.509$, $P<0.001$) [19]. In this study, no significant correlation was found between vein diameter and stump length at <1 month and 6 months after the procedure.

Studies on the outcome of CAC treatment for saphenous vein incompetence have been continuously published. Almeida et al. [1] reported the results of the first use of CAC in humans. Thirty-eight patients with GSV incompetence exhibited an occlusion rate of 92.0% at 6 months and maintenance of occlusion of up to 12 months. Subsequently, in a European prospective multicenter cohort study [2], similar results were reported with an occlusion rate of 92.9% at 12 months. In a randomized controlled trial (VeClose), the occlusion rates in the CAC and RFA groups were 99% and 96% at 3 months [3], 97.2% and 97.0% at 12 months [4], 95.3% and 94.0% at 24 months [5], and 94.4% and 91.9% at 36 months, respectively [6]. No significant

difference in occlusion rates was observed during the study period. However, the recanalization-free rate in our study was lower in the CAC group than in the RFA group (77.2% vs. 100%) at 6 months.

To exclude the possibility of recanalization because of initial technical failure, we examined the change in stump length at 6 months and compared it with the stump length at the first outpatient clinic visit. Of a total of 57 CACs, recanalization was observed in 3 (5.3%) veins at <1 month and in 13 (22.8%) veins at 6 months, and 5 (8.8%) veins had a >5 cm increase in stump length between the first visit and the 6-month follow-up, including four SSVs and one GSV.

In all procedures in this study, the catheter tip was located 5 cm distal to the SFJ/SPJ. In the first use of CAC in humans [1], the incidence of EGIT was as high as 21% when the catheter was placed at a distance of 4 cm from the SFJ/SPJ. Since then, the manufacturer's instructions for use have been adopted by positioning the catheter tip at a distance of 5 cm from the SFJ/SPJ. In this study, three pa-

tients (5.3%) had EGIT. All three patients had grade 2 EGIT, and no symptoms were observed. All patients with EGIT were conservatively treated and showed reduced thrombosis extent on DUS at the 6-month follow-up. Cho et al. [20] reported that a SSV diameter (<5 mm) is a risk factor for EGIT. The results of this study are consistent with those of previous studies [20,21]. The median diameter of the saphenous vein with EGIT was 0.39 cm (interquartile range 0.15–0.41 cm), and the median diameter of the saphenous vein without EGIT was 0.51 cm (interquartile range 0.42–0.63 cm) (P=0.040). Other potential risk factors include diabetes, hypertension, and hyperlipidemia.

This study had some limitations. First, the small sample size from a single center may weaken the reliability of the results. To analyze factors affecting stump length, a larger sample size is warranted to increase the reliability of the analysis. Second, long-term results on stump length changes were not analyzed because surveillance with DUS was terminated at 6 months after treatment in most patients. However, in some patients who underwent DUS until after ≥1 year, the stump length observed at 6 months was consistently maintained during the follow-up, suggesting that the long-term results may not be different from the findings observed in this study.

CONCLUSION

The stump length significantly increased at 6 months after CAC or RFA. A significantly larger increase in stump length was observed in the CAC group than in the RFA group. Vein diameter was not related with the stump length

increase and no other factors affected the changes in stump length. Careful observation is needed after CAC treatment because an increase in stump length can lead to recanalization and recurrent varicose veins.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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AUTHOR CONTRIBUTIONS

Concept and design: SKM. Analysis and interpretation: all. Data collection: HK, JK. Writing the article: HK, SKM. Critical revision of the article: HK, SM, SA, AH, SKM. Final approval of the article: all. Statistical analysis: HK. Obtained funding: none. Overall responsibility: SKM.

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