



Superficial venous procedures can be performed safely and effectively in patients with deep venous reflux

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ABSTRACT

Background: The finding of concurrent deep venous reflux (DVR) when interrogating superficial venous reflux is common and might be a marker of more severe chronic venous insufficiency. However, the safety and clinical and patient-reported outcomes for patients undergoing superficial venous treatment in the presence of DVR remains underreported. Moreover, the factors associated with the persistence and disappearance of DVR after superficial vein treatment have not been evaluated. In the present study, we sought to address these questions.

Methods: We performed a review of the institutional vascular quality initiative database from June 2016 to June 2021. Consecutive patient limbs were identified that had undergone a superficial venous intervention and had duplex ultrasound evaluations available. These patients were divided into those with and without DVR. Those with DVR were further reviewed for anatomic details and the persistence or resolution of DVR after the procedure. The primary outcome was the venous clinical severity score (VCSS) at a follow-up >3 months. The secondary outcomes included the incidence of any postoperative deep vein thrombosis or endovenous heat-induced thrombosis, differences in patient-reported outcomes, rate of resolution of DVR, and factors associated with DVR persistence. Both univariate analysis and multivariate logistic regression were applied.

Results: Of the patients who had undergone superficial venous treatment, 644 patient limbs had had DVR and 7812 had not, for a prevalence of 7.6%. The DVR group was associated with a higher burden of chronic venous insufficiency. On univariate analysis, patient limbs, both with and without DVR, had improved significantly in the VCSS at <3 months of follow-up and were not significantly different. At >3 months of follow-up, the VCSS had again improved significantly compared with the VCSS at <3 months of follow-up. However, the difference between the two groups was statistically significant at the longer interval. The magnitude of improvement in the VCSS between the two groups at the longer follow-up were similar statistically (VCSS, 3.17 ± 3.11 vs 3.03 ± 2.93 ; $P = .739$). The HASTI (heaviness, achiness, swelling, throbbing, itching) score had similarly improved significantly in both groups but remained significantly higher in the DVR group during follow-up. On multivariate logistic regression, DVR was not associated with an increased VCSS at >3 months of follow-up. No intergroup difference was found in the incidence of postoperative deep vein thrombosis or endovenous heat-induced thrombosis. Of limbs with DVR, 40.8% no longer had evidence of detectable DVR at the latest follow-up venous duplex ultrasound, and DVR limited to a single segment was more likely than DVR in multiple segments to be no longer detectable.

Conclusions: Our results have shown that superficial venous procedures are safe and effective in patients with DVR, leading to improvements in clinical and patient-reported outcomes similar to those for patients without DVR. In a large proportion of the treated limbs, especially those with DVR in a single segment, no evidence of DVR was found after superficial venous intervention. Although patients with DVR will have a higher burden of chronic venous insufficiency, they still appear to derive significant benefit from superficial venous treatment. (*J Vasc Surg Venous Lymphat Disord* 2023;11:281-92.)

Keywords: Chronic venous insufficiency; Deep vein; Deep venous reflux; Valvular reflux; Venous reflux

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A survey of the prevalence of chronic venous insufficiency in the United States identified varicose veins in >30% and more advanced venous disease in >10% of the participants.¹ The incidence of venous thromboembolism and, subsequently, its sequelae have also been increasing, which could exacerbate the superficial venous disease burden.² The development of reflux in a deep venous segment can occur primarily or can result from damage to the valve from the thrombotic process. Also, two thirds of patients will have valvular incompetence 1 year after deep vein thrombosis (DVT).³ The finding of concurrent deep venous reflux (DVR) when interrogating superficial venous reflux has become common and might be a marker for more severe chronic venous insufficiency symptoms.^{4,5}

Although the reported data and studies of superficial venous reflux and its treatment have been increasing, few studies have investigated the implications of DVR on superficial venous treatment. Few studies have investigated the treatment of superficial veins in patients with deep venous disease such as reflux or thrombosis. However, the limited data available have suggested some improvements in symptoms with this approach.^{6,7} Moreover, the comparative clinical and patient-reported outcomes after superficial venous procedures for patients with and without DVR has remained underreported. Furthermore, very few studies have reported on the anatomic distribution of DVR and whether it will persist or resolve after superficial venous treatment. Finally, to the best of our knowledge, the incidence of DVR in a contemporary, real-world vein practice has not yet been delineated. This is important, especially with new treatment modalities for DVR on the horizon.^{8,9} In the present study, we sought to address these questions by analyzing the data from a high-volume academic vein practice.

METHODS

In the present study, we reviewed the New York University Langone Health Vascular Quality Initiative (VQI) venous database from June 2016 to June 2021. The institutional review board approved the study and waived the requirement for patient informed consent.

Consecutive patient limbs were identified that had undergone interventional or surgical treatment of the superficial or perforator veins and had had duplex ultrasound evaluations of the corresponding limb. Interventional treatment included radiofrequency ablation, endovenous laser ablation, and the nonthermal techniques of mechanico-chemical, chemical, and embolic adhesive. Surgical treatments included high ligation and stripping and microphlebectomy, with the latter used as adjunctive therapy when indicated. All treatment modalities were included to approximate real world practice.

DVR has been defined by the VQI as reflux of >0.5 second in any deep vein on duplex ultrasound.

ARTICLE HIGHLIGHTS

- **Type of Research:** A retrospective analysis of prospectively collected institutional Vascular Quality Initiative data of patients who had undergone superficial vein treatment with and without concurrent deep venous reflux (DVR)
- **Key Findings:** Patients with DVR had a higher disease burden but still experienced improvement in clinical and patient-reported outcomes at follow-up. Patients without DVR also had improvement in outcomes after superficial vein treatment. A large proportion of the DVR cases, especially those limited to a single segment, were undetectable on the latest follow-up duplex ultrasound after superficial vein procedures.
- **Take Home Message:** DVR itself was not associated with a poorer outcome after superficial vein treatment and should not deter intervention.

The common femoral vein, femoral vein, and popliteal vein were the three deep vein segments interrogated by the institutional vascular laboratory during a complete venous reflux study for each treated limb. The patient limbs were divided into those with and without DVR using the VQI definition. The baseline characteristics and clinical and patient-reported outcomes at early and late follow-up were compared between the two groups. The VQI has defined early follow-up as 0 to 3 months after the procedure and late follow-up as >3 months after the procedure. The clinical outcomes included the CEAP (Clinical, Etiology, Anatomy, Pathophysiology) class and the venous clinical severity score (VCSS) for the treated limb. The patient-reported HASTI (heaviness, achiness, swelling, throbbing, itching) score includes the following scale for each of the five components: 0, none of the time; 1, a little of the time; 2, some of the time; 3, a good bit of the time; 4, most of the time; and 5, all of the time, for a total possible score of 25. The appearance scale is as follows: 0, not at all noticeable; 1, slightly noticeable; 2, moderately noticeable; 3, very noticeable; and 4, extremely noticeable. The scale for the effects on work or activity is as follows: 0, none; 1, symptoms but full work or activity; 2, mildly reduced work or activity; 3, moderately reduced work or activity; 4, severely reduced work or activity; and 5, unable to do work or activity.

The patient limbs in the DVR group were individually reviewed, and data unavailable from the VQI database, such as the anatomic location of the reflux, persistence or resolution on the latest complete venous duplex ultrasound after the index superficial vein procedure, and the rate of deep venous interventions, were recorded. Anatomically, the DVR patient limbs were segregated into those with common femoral vein only, femoral

Table I. Baseline characteristics and univariate outcomes stratified by follow-up and deep venous reflux (DVR)

Variable	DVR		P value
	Yes	No	
Baseline			
Patient limbs, No.	644	7812	
Age, years	58.38 ± 15.39	53.42 ± 14.63	<.001
Female sex	48.1 (310)	70.3 (5494)	<.001
White race	70.0 (451)	71.6 (5595)	.389
Private insurance or self-pay	65.2 (420)	72.1 (5635)	<.001
BMI, kg/m ²	28.01 ± 6.34	27.24 ± 6.34	.003
BMI >30 kg/m ²	66.5 (427)	57.3 (4469)	<.001
History of DVT	17.1 (109)	6.6 (511)	<.001
Current anticoagulation use	10.1 (65)	3.7 (286)	<.001
History of superficial vein treatment	55.8 (353)	52.5 (4046)	.116
History of phlebitis	22.2 (141)	13.4 (1039)	<.001
Compression use	25.5 (164)	21.0 (1637)	.009
≥3 Pregnancies	35.5 (142)	29.7 (1078)	.081
CEAP class			<.001
0	0 (0)	0 (0)	1.00
1	0.5 (3)	0.4 (29)	1.00
2	24.4 (157)	35.6 (2782)	<.001
3	31.7 (204)	38.3 (2992)	<.001
4a	22.8 (147)	16.6 (1298)	<.001
4b	4.7 (30)	2.5 (196)	.001
5	3.6 (23)	1.9 (145)	.004
6	12.6 (80)	4.7 (370)	<.001
VCSS	6.82 ± 3.44	5.79 ± 2.82	<.001
VCSS ≥4	87.2 (558)	82.0 (6385)	.001
HASTI score			
Overall score	8.36 ± 3.45	7.91 ± 3.36	.01
Moderate, very, or extremely noticeable appearance	86.1 (346)	83.6 (4210)	.206
Moderate, severe, or unable to work	22.3 (90)	22.7 (1144)	.902
Right side treated	49.4 (318)	48.6 (3797)	.712
Veins treated, No.	2.67 ± 1.84	2.48 ± 1.54	.003
GSV treated	68.0 (335)	77.5 (4112)	<.001
SSV treated	24.7 (122)	14.4 (763)	<.001
Perforation vein treated	3.7 (24)	1.2 (94)	<.001
Treatment			
Radiofrequency ablation	65.7 (423)	60.0 (4687)	.005
Laser ablation	14.0 (90)	8.5 (664)	<.001
Ligation, stripping, or microphlebectomy	19.7 (127)	31.2 (2437)	<.001
DVT on duplex ultrasound	6.6 (42)	1.5 (120)	<.001
<3 Months of follow-up			
Patients, No.	63	892	
CEAP class			.599
0	3.2 (2)	2.9 (26)	.707
1	15.9 (10)	16.8 (150)	1.00

(Continued on next page)

Table I. Continued.

Variable	DVR		P value
	Yes	No	
2	60.9 (39)	63.7 (564)	.593
3	7.8 (5)	11.4 (101)	.395
4a	3.1 (2)	1.8 (16)	.436
4b	0 (0)	0.5 (4)	1.00
5	1.6 (1)	0.7 (6)	.411
6	6.3 (4)	2.8 (25)	.113
VCSS	4.83 ± 3.02 ^a	4.48 ± 2.60 ^a	.308
VCSS ≥4	69.8 (44)	71.8 (627)	.772
HASTI score			
Overall score	4.11 ± 2.75 ^a	2.90 ± 1.96 ^a	<.001
Moderate, very, or extremely noticeable appearance	38.3 (18)	30.5 (157)	.323
Moderate, severe, or unable to work	4.3 (2)	2.9 (15)	.645
Any DVT/EHIT	2.0 (7)	1.2 (51)	.215
Recanalization of treated vein	0.3 (1)	0.4 (13)	1.00
>3 Months of follow-up			
Patients, No.	60	585	
CEAP class			
0	5 (3)	12.5 (73)	.095
1	16.7 (10)	35.0 (205)	.004
2	29.2 (19)	29.5 (175)	.945
3	13.8 (9)	12.0 (71)	.757
4a	18.5 (12)	7.1 (42)	.003
4b	1.5 (1)	0.3 (2)	.151
5	6.2 (4)	1.7 (10)	.012
6	3.1 (2)	1.2 (7)	.179
VCSS	3.50 ± 2.55 ^{a,b}	2.46 ± 2.32 ^{a,c}	.001
VCSS improvement from preoperatively	3.17 ± 3.11	3.03 ± 2.93	.739
VCSS ≥4	48.3 (29)	28.6 (167)	.003
HASTI score			
Overall score	1.78 ± 1.47 ^{a,c}	1.18 ± 1.30 ^{a,c}	.036
Moderate, very, or extremely noticeable appearance	26.1 (6)	13.4 (37)	.117
Moderate, severe, or unable to work	0 (0)	1.4 (4)	1.00
Recanalization of treated vein	1.9 (2)	1.3 (13)	.646

BMI, Body mass index; CEAP, Clinical, Etiology, Anatomy, Pathophysiology; DVT, deep vein thrombosis; EHIT, endovenous heat-induced thrombus; GSV, great saphenous vein; HASTI, heaviness, achiness, swelling, throbbing, itchiness; SSV, small saphenous vein; VCSS, venous clinical severity score. Data presented as percentage (number) for nominal variables or mean ± standard deviation.

^aP < .001 vs preoperatively.

^bP = .01 vs <3 months.

^cP < .001 vs <3 months.

vein only, popliteal vein only, and all combinations of the three segments, similar to the axial and segmental classification of DVR proposed by Lim et al.¹⁰ The patient limbs with DVR that was no longer detectable on follow-up were categorized as undetected and were compared with those with persistent DVR. The latest

complete venous reflux duplex ultrasound examinations that had used augmentation maneuvers in the deep vein were used. Those without a complete venous duplex ultrasound examination were excluded from this subanalysis. Deep venous interventions included ipsilateral iliac venous angioplasty and stenting.

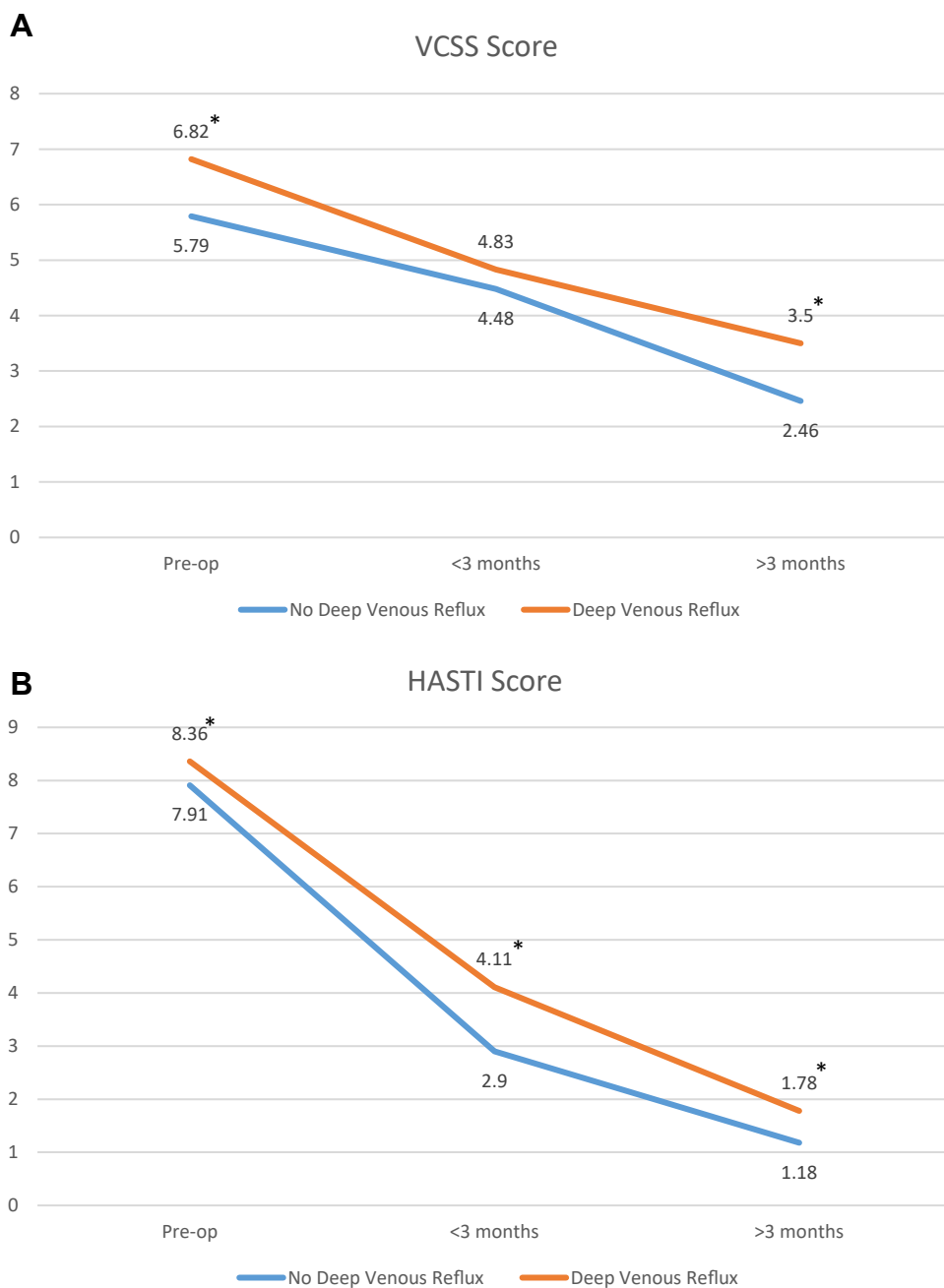


Fig 1. Linear trend plot of venous clinical severity score **(A)** VCSS and **(B)** HASTI (heaviness, achiness, swelling, throbbing, itching) score after superficial vein treatment between patients with and without deep venous reflux (DVR) at <3 and >3 months of follow-up. Comparisons of the scores between preoperatively (*pre-op*) and <3 months of follow-up and between <3 months of follow-up and >3 months of follow showed that the decreases in the **(A)** VCSS and **(B)** HASTI scores were statistically significant in both groups. *Statistically significant difference between those with and without DVR. VCSSs were not significantly different statistically at <3 months.

The primary outcome for the present study was the VCSS at >3 months of follow-up. The secondary outcomes included the incidence of any postoperative DVT or endovenous heat-induced thrombosis (EHIT), patient-reported outcomes, including the HASTI score,

appearance, and effect on work ability, and the absence of DVR on the latest venous duplex ultrasound.

The results are reported as percentages for discrete variables and as the mean ± standard deviation for continuous variables. The χ^2 test was used for discrete

Table II. Multivariable analysis^a of postoperative outcomes for patients with deep venous reflux (DVR; with no DVR as reference)

Outcomes	HR	95% CI	P value
VCSS >4 after 3 months	0.693	0.22-2.2	.536
Any postoperative DVT or EHIT	0.1	0.02-0.51	.005
Moderate, very, or extremely noticeable appearance	1.226	0.39-3.822	.726
Swelling some of the time or more often	0.798	0.191-3.337	.757

CI, Confidence interval; *DVT*, deep vein thrombosis; *EHIT*, endovenous heat-induced thrombosis; *HR*, hazard ratio; *VCSS*, venous clinical severity score.
^aAdjusted for age, White race, commercial insurance or self-pay, current anticoagulation use, number of pregnancies, history of superficial phlebitis, history of DVT, prior varicose vein treatment, ipsilateral compression use, ipsilateral DVT on duplex ultrasound, preoperative VCSS, preoperative CEAP (Clinical, Etiology, Anatomy, Pathophysiology) class \geq 4b.

variables and the Student *t* test for continuous variables. Both univariate analysis and multivariate logistic regression were applied. $P < .05$ was considered to indicate statistical significance. Statistical analyses were performed using SPSS, version 25.0 (IBM Corp, Armonk, NY).

RESULTS

A total of 8456 consecutive patient limbs were evaluated, of which 644 had had DVR and 7812 had not, for an incidence of 7.6%. On univariate analysis, the DVR group was associated with older age, higher body mass index (BMI), a history of DVT, anticoagulation therapy, phlebitis, and concurrent DVT found on the duplex ultrasound. Clinically, the DVR patients had had a higher CEAP class and VCSS. The DVR group had had a lower incidence of great saphenous vein treatment and microphlebectomy, a higher incidence of small saphenous vein and perforator treatment, and a greater number of veins treated. Other baseline characteristics, including White race, side treated, and effects on work did not differ significantly between the two groups (Table I).

On univariate analysis, the patient limbs both with and without DVR had improved significantly in the VCSS at the early (<3-month) follow-up but did not differ significantly when compared with each other (VCSS, 4.83 ± 3.02 vs 4.48 ± 2.60 ; $P = .308$; Fig 1). The CEAP class overall was not significantly different statistically at <3 months follow-up (Supplementary Fig, online only). At the late, >3-month, follow-up, the VCSS had again improved significantly compared with that at <3 months of follow-up. However, the difference between the two groups had become statistically significant (VCSS, 3.50 ± 2.55 vs 2.46 ± 2.32 ; $P = .001$; Fig 1). The same was true for the overall CEAP class distribution, with the DVR group having a greater prevalence of C4a and C5 compared with the no DVR group (Supplementary Fig, online only). Nonetheless, the rate of VCSS improvement from preoperatively to >3 months of follow-up was not significantly different statistically between the DVR and no DVR group after superficial vein treatment (VCSS, 3.17 ± 3.11 vs 3.03 ± 2.93 ; $P = .739$). Of those who had

initially presented with C6 disease, 257 ulcers were in the DVR group and 194 in the no DVR group. At <3 months of follow-up, the corresponding number of ulcers was 133 and 109. At >3 months of follow-up, of the patients who had initially presented with C6 disease, 136 and 56 ulcers were in the DVR and no DVR groups, respectively.

In the patient-reported outcomes, the HASTI score was consistently higher for those with DVR but had improved significantly after superficial venous treatment for both groups at follow-up (Fig 1). The effects on work had improved from preoperatively to <3 months and from preoperatively to >3 months of follow-up. The difference between those with and without DVR at each follow-up interval was not statistically significant. Differences in the incidence of treatment-associated DVT or EHIT and the recanalization of treated veins at <3 months of follow-up were not statistically significant between those with and without DVR (Table I).

On multivariate logistic regression, DVR was not associated with an increased VCSS, when defined as a VCSS of >4 at >3 months of follow-up. DVR was also not associated with a difference in appearance or swelling some of the time or more during follow-up (Table II). No intergroup difference was found in the incidence of postoperative DVT or EHIT on univariate analysis. However, multivariate logistic regression showed that DVR was associated with a lower incidence of postoperative DVT and EHIT (odds ratio [OR], 0.1; 95% confidence interval [CI], 0.02-0.51; $P = .005$). The only independent positive predictor of a VCSS of >4 at >3 months of follow-up was an increased BMI (OR, 1.089; 95% CI, 1.038-1.142; $P < .001$). The independent negative predictors were compression use (OR, 0.455; 95% CI, 0.228-0.910; $P = .026$) and commercial insurance or self-pay (OR, 0.388; 95% CI, 0.156-0.960; $P = .041$; Fig 2).

Each treated patient limb in the DVR group was reviewed further, and those patient limbs with persistent DVR on the latest venous duplex ultrasound after the index superficial vein procedure were compared with those with DVR that was no longer detectable

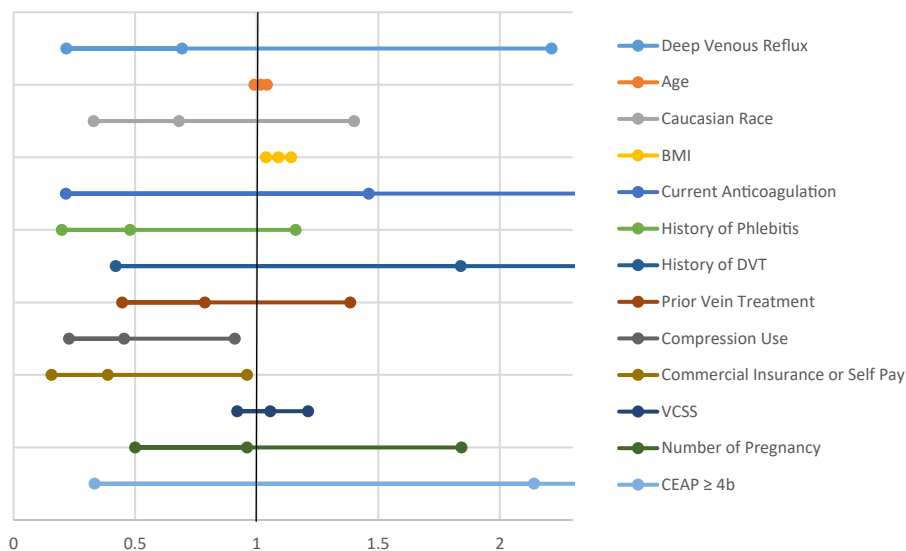


Fig 2. Forest plot of multivariate linear regression for predictors of venous clinical severity score (VCSS) of >4 at >3 months of follow-up. An increased body mass index (BMI) was independently associated with VCSSs >4. Compression use and commercial insurance or self-pay were independently associated with a lower prevalence of VCSSs >4. Deep venous reflux (DVR) was not associated with VCSSs >4. CEAP, Clinical, Etiology, Anatomy, Pathophysiology; DVT, deep vein thrombosis.

(Table III). In 40.8% of the patient limbs, DVR was no longer detectable at the latest venous duplex ultrasound examination. The anatomic distribution and laterality of DVR are listed in Table III. Compared with the persistent DVR group, the undetectable group had had a greater incidence of isolated common femoral vein reflux, single segment vein reflux (vs multiple segments of reflux), and DVR ipsilateral to the treated limb (vs bilateral DVR). The undetectable group had had a lower incidence of combined femoral and popliteal vein reflux and a greater incidence of female sex and White race. The patient limbs with persistent DVR had had a higher incidence of a history of DVT, current anticoagulation use, compression use most days or daily, C5 and C6 class, and bilateral DVR and had had a trend toward a higher VCSS and greater rate of deep venous intervention. Other characteristics, such as age, BMI, number of pregnancies, initial patient-reported outcomes, side treated, and length ablated were not significantly different statistically between those with and without persistent DVR.

The rate of DVR detectability, grouped by anatomic DVR location, on the follow-up duplex ultrasound after superficial vein treatment is shown in Fig 3. Compared with the overall rate of resolution of 40.8%, DVR isolated to the common femoral vein had had a significantly higher rate of resolution statistically ($P < .001$) and combined femoral and popliteal DVR, a significantly lower rate of resolution statistically ($P = .008$). The group with DVR in all three segments had also had a lower rate of resolution; however, the difference did not reach statistical significance ($P = .09$). The other anatomic groups of DVR were not significantly different statistically from

the overall rate of DVR resolution. A total of 19 deep vein interventions had been performed in the DVR cohort (6.74%). Also, although not statistically significant, a trend was found toward a greater rate of deep venous interventions for those with persistent DVR (8.98% vs 3.48%; $P = .07$; Table III). For those with persistent DVR, the deep vein interventions had included 12 cases of iliac vein stenting and 3 cases of isolated venoplasty. For those with undetectable DVR, the deep vein interventions had included two cases of iliac vein stenting and two cases of isolated venoplasty.

DISCUSSION

The descending theory of chronic venous insufficiency proposes that axial reflux in the superficial veins originates centrally due to incompetence of the saphenofemoral junction or higher.¹¹ Iliofemoral DVT and May-Thurner syndrome can lead to DVR, which can then transmit hydrostatic pressure peripherally, possibly leading to clinically significant superficial venous reflux.¹² These central venous pathologies and reflux can be additional aggravators to an individual with chronic venous insufficiency from superficial venous incompetency. It has also been shown that DVR will be associated with superficial venous reflux in one half of the patients presenting with severe chronic venous insufficiency.¹³ The univariate analysis revealed that the group with DVR had had a higher incidence of comorbidities associated with more severe chronic venous insufficiency. This might have resulted from the increased burden related to post-thrombotic syndrome, presentation at later disease stages, or other risk factors that predispose to a

Table III. Anatomic details, baseline and procedural characteristics, and rate of deep venous intervention stratified by persistent deep venous reflux (DVR)

Variable	Persistent DVR		P value
	Yes (n = 167; 60.2%)	No (n = 115; 40.8%)	
Prevalence of DVR			
Distribution			
CFV (n = 24; 8.51%)	1.20 (2)	19.13 (22)	<.001
FV (n = 32; 11.35%)	10.78 (18)	12.17 (14)	.678
PV (n = 118; 41.84%)	40.72 (68)	43.48 (50)	.644
CFV + FV (n = 6; 2.13%)	1.80 (3)	2.61 (3)	.642
FV + PV (n = 75; 26.60%)	34.13 (57)	15.65 (18)	<.001
CFV + PV (n = 8; 2.84%)	2.40 (4)	3.48 (4)	.59
CFV + FV + PV (n = 19; 6.74%)	8.98 (15)	3.48 (4)	.07
Segment			
Single	52.69 (88)	74.78 (86)	<.001
Multiple	47.31 (79)	25.22 (29)	<.001
DVR ipsilateral to treated limb	50.90 (85)	68.70 (79)	.003
DVR contralateral to treated limb	2.40 (4)	1.74 (2)	.708
Bilateral DVR	46.71 (78)	29.57 (34)	.004
Baseline characteristics			
Age, years	61.47 ± 14.91	59.12 ± 15.81	.205
Female sex	37.13 (62)	53.91 (62)	.005
White race	65.87 (110)	78.26 (90)	.024
Private insurance or self-pay	56.29 (94)	62.61 (72)	.289
BMI, kg/m ²	28.38 ± 5.67	27.07 ± 5.86	.054
History of DVT	26.35 (44)	14.78 (17)	.020
Current anticoagulation use	19.16 (32)	8.70 (10)	.015
History of superficial vein treatment	63.41 (106)	54.39 (63)	.131
History of phlebitis	28.14 (47)	23.48 (27)	.381
Pregnancies, No.	1.72 ± 1.93	1.93 ± 1.83	.617
Compression use most days or daily	29.94 (50)	16.52 (19)	.021
CEAP class			
0	0 (0)	0 (0)	1.00
1	0 (0)	0 (0)	1.00
2	19.88 (34)	26.67 (32)	.174
3	21.64 (37)	40.83 (49)	<.001
4a	26.32 (45)	18.33 (22)	.111
4b	6.43 (11)	4.17 (5)	.404
5	7.02 (12)	1.67 (2)	.036
6	18.71 (32)	8.33 (10)	.013
VCSS	7.67 ± 6.26	6.47 ± 4.97	.081
HASTI score			
Overall score	7.87 ± 3.51	8.25 ± 3.57	.370
Moderate, very, or extremely noticeable appearance	47.95 (82)	49.17 (59)	.838
Moderate, severe, or unable to work	9.36 (16)	11.67 (14)	.524
Procedural information			
Left side treated	56.29 (90)	57.39 (59)	.854
Truncal vein	71.86 (120)	83.48 (96)	.023
Remnant/recanalized truncal vein	5.39 (9)	2.61 (3)	.256
Perforator vein	6.59 (11)	5.22 (6)	.635

Table III. Continued.

Variable	Persistent DVR		P value
	Yes (n = 167; 60.2%)	No (n = 115; 40.8%)	
Microphlebectomy	16.17 (27)	8.70 (10)	.068
Length ablated, cm	33.33 ± 13.04	30.70 ± 14.85	.117
Deep venous intervention (n = 19; 6.74%)	8.98 (15)	3.48 (4)	.070

BMI, Body mass index; *CFV*, common femoral vein; *FV*, femoral vein; *DVT*, deep vein thrombosis; *PV*, popliteal vein; *VCSS*, venous clinical severity score. Data presented as percentage (total number of patient limbs) or mean ± standard deviation. Boldface P values represent statistical significance.

more advanced presentation. The initial pathophysiologic processes that lead to DVR require further study. However, even the clinical and patient-reported outcomes after superficial vein treatment in conjunction with DVR treatment are lacking. Some studies have reported the possible resolution of DVR when the superficial veins were treated. However, corroboration with larger cohort studies and the identification of factors associated with the persistence or disappearance of DVR are needed.

The findings from the present retrospective cohort study have underscored that patient limbs with and without DVR will both experience significant improvement in objective clinical scores and patient-reported outcomes after superficial venous treatment. Although patient limbs with DVR had exhibited more severe chronic venous insufficiency at baseline, the VCSSs had improved significantly in both the DVR and the no DVR groups, and the improvement was >3 points in both

groups at >3 months of follow-up (Table I). Patient-reported outcomes such as the HASTI score and effect on work all improved significantly in both groups. Although at >3 months of follow-up, the worse clinical manifestation in the group with DVR had again become apparent, this was likely related to the worse initial clinical presentation and more prevalent risk factors in the DVR group. Our findings have highlighted that patients with DVR can still derive significant benefit from superficial vein procedures; thus, the presence of DVR should not deter intervention. In addition, the incidence of DVT or EHIT was not significantly different statistically between those with and without DVR, further supporting the safety of superficial vein treatment for patients with DVR.

Other investigators have shown that superficial venous procedures for patients with DVR are safe and effective in clinical improvement and ulcer healing, although these studies were limited and only included procedures

Reflux Persistence or Resolution

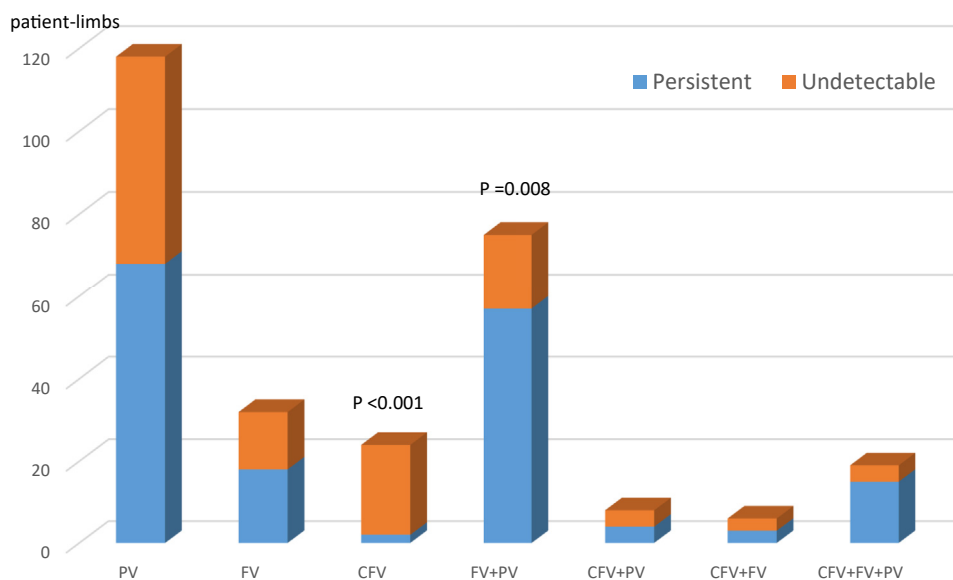


Fig 3. Deep venous reflux (DVR) persistence or resolution on venous duplex ultrasound after superficial vein procedures, segregated by anatomic DVR distribution. P values provided for differences that were statistically significant than overall DVR resolution rate of 40.8%. *CFV*, Common femoral vein; *FV*, femoral vein; *PV*, popliteal vein.

on saphenous veins.¹⁴⁻¹⁶ Brown et al¹⁷ used the national VQI venous database and found that great saphenous vein ablation in patients with concomitant DVR had improvement in the VCSS but that the presence of DVR was associated with a higher complication rate after truncal ablation. They had not included phlebectomy or treatment of nontruncal veins, limiting the generalizability of their results. We attempted to reflect real world practice by using data from an academic practice with a high volume of venous procedures. Also, we included all superficial venous interventions such as truncal and remnant vein ablation, phlebectomy, and perforator vein ablation to increase the generalizability.

In the present study, we found a prevalence of DVR in our current and broad cohort of patients with venous insufficiency of 7.6%. This prevalence appears to be lower than that found in a cross-sectional study of a general European population, which had reported that $\leq 20.0\%$ of enrolled subjects had had reflux in at least one deep vein.¹⁸ This difference might stem from differences in the demographic data and ultrasound reporting. One known consideration is that the diagnosis of DVR is not required by the current Intersocietal Accreditation Commission guidelines for lower extremity venous duplex ultrasound.¹⁹ This could result in skewed reporting in the literature, skewed practice patterns in a real world setting, and could possibly also have introduced an element of selection bias.

At a follow-up of >3 months, the VCSS for the DVR group was significantly higher statistically than that for the non-DVR group. Also, the HASTI score for the DVR group was higher at all intervals, highlighting the importance of continued monitoring and optimization for the DVR group. Other studies have also shown that DVR confers a poorer prognosis, especially for the ulcer healing rate; thus, continued optimization such as compression use is paramount for this group.²⁰⁻²² This could be an impetus for further evaluation and possible treatment of underlying DVR, and multiple clinical trials are currently underway to address this.^{8,9} Nonetheless, the presence of DVR was not associated with a higher follow-up VCSS on multivariate logistic regression (Table II). The factor that was associated with a higher VCSS was the BMI, and the factors associated with a lower VCSS were compression use and private insurance or self-pay (Fig 2). A higher BMI and the consistent use of compression were previously shown to affect the clinical outcomes after superficial venous treatment.^{23,24} Insurance status has not been shown to correlate with the clinical outcomes after superficial venous interventions, and further investigation is required to better understand this relationship.

When the patient limbs with DVR were individually reviewed, further anatomic details of the DVR were extracted, which are not included in the VQI database. We found that, overall, 40.8% of the DVR was undetected

on the latest follow-up with complete venous reflux duplex ultrasound assessing deep and superficial vein incompetency. This finding has corroborated other reports from smaller series that 30% to 50% of segmental DVR will have resolved after saphenous vein surgery or ablation.^{16,25,26} Those with persistent DVR likely had had worse chronic venous insufficiency or had had post-thrombotic syndrome, as reflected by the higher prevalence of a history of DVT, anticoagulation and compression use, combined femoropopliteal vein reflux, and bilateral limb reflux and a trend toward a higher VCSS and incidence of deep vein intervention. These findings further support that unless central vein pathologies such as iliofemoral DVT or May-Thurner syndrome are suspected, the finding of segmental DVR in a patient free of post-thrombotic risk factors should not deter the use of superficial vein intervention, because subsequent resolution of the DVR might occur. When separated by the anatomic distribution of DVR, only common femoral vein reflux was more likely to resolve after superficial vein treatment. In contrast, multiple axial DVR in the femoral and popliteal veins was more likely to be persistent. This might be explained by the descending theory of chronic insufficiency and that improving the incompetence of a superficial vein might possibly lead to a decreased potential reservoir for reflux and resolution of an isolated common femoral DVR.¹¹ In contrast, more extensive DVR continuing down to the popliteal vein might be a reflection of more severe valvular incompetence or damage from post-thrombotic anatomy, which might result in a greater incidence of persistent reflux.

The study limitations included those inherent to a retrospective review of a large dataset, including the possibility of confounding factors, incomplete data, and selection bias for the patient limbs with follow-up data available. Given its retrospective nature, our study was hypothesis generating, and further prospective studies are needed to validate the presence of a similar benefit for superficial vein treatment for those with and without DVR. Furthermore, additional study is required to identify the factors associated with ongoing poor clinical and patient-reported outcomes for patients with DVR, as shown by the still inferior VCSSs and HASTI scores at longer term follow-up compared with the scores for those without DVR. Venous duplex ultrasound is a technician-dependent examination, and although DVR has been assessed routinely at our institution on complete venous duplex ultrasound examinations for edema, there could have been false-negative findings or cases of missed DVR, resulting in a higher perceived rate of DVR resolution on follow-up duplex ultrasound. The VQI has defined DVR as reflux in the deep vein of >0.5 second. However, the widely accepted definition for DVR is reflux of >1 second.²⁷ The VQI might consider changing the definition of DVR in the future to prevent overinclusion

of DVR. The exact anatomic location of DVT and DVR and their persistence or resolution are not recorded in the VQI; however, the inclusion of these variables would further augment future research and quality improvement endeavors. Many of our patients had had a history of DVT without duplex ultrasound evidence of DVT found by our review of the medical records from our institution. Therefore, we could not infer how a prior DVT might have contributed to DVR location, persistence, or resolution. Determination of a more detailed association between DVT and DVR requires further evaluation. In the multivariate logistic regression model, DVR was associated with a lower incidence of postoperative DVT or EHIT. This finding bodes well for the safety of treatment but requires further prospective validation. The concomitant treatment of superficial venous reflux, DVR, and central venous obstruction also requires study and prospective follow-up.

CONCLUSIONS

In the present study, the incidence of DVR in patients undergoing superficial vein treatment was 7.6%. Our results have shown that superficial venous intervention for patients with DVR is safe and effective, leading to significant improvements in clinical and patient-reported outcomes, just as they did for those without DVR. Although patients with DVR had a higher burden of chronic venous insufficiency, it appears that DVR itself is not associated with poorer outcomes after superficial vein treatment. Furthermore, for 40.8% of the treated limbs, DVR was no longer detectable on subsequent duplex ultrasound evaluation. We also found that DVR in a single segment, especially in the common femoral vein, was more likely to resolve and that DVR in multiple segments was more likely to persist. Thus, the presence of DVR should not deter physicians from treating any associated superficial vein disease.

AUTHOR CONTRIBUTIONS

Conception and design: CL, GJ, MS

Analysis and interpretation: CL, GJ, CR, TM, TB, KG, MB, MS

Data collection: CL, MS

Writing the article: CL, MS

Critical revision of the article: CL, GJ, CR, TM, TB, KG, MB, MS

Final approval of the article: CL, GJ, CR, TM, TB, KG, MB, MS

Statistical analysis: CL, MS

Obtained funding: Not applicable

Overall responsibility: MS

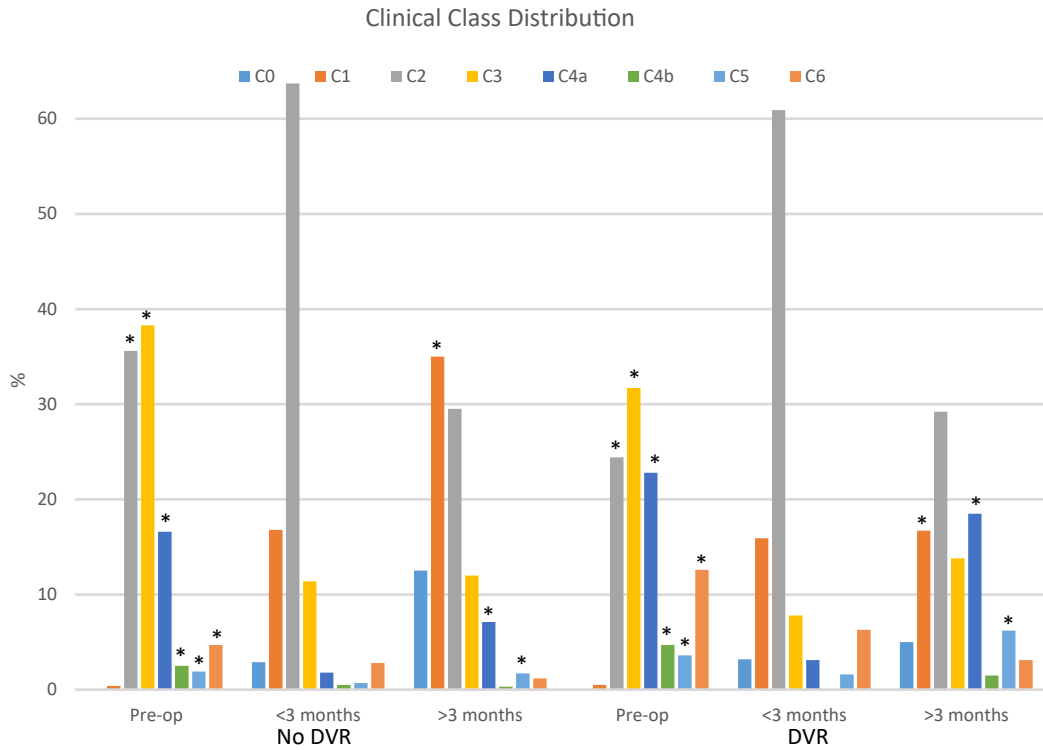
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Additional material for this article may be found online at www.jvsvenous.org.



Supplementary Fig (online only). Clinical class distribution from C0 to C6 shown preoperatively, at <3 months of follow-up, and at >3 months of follow-up stratified by presence of deep venous reflux (DVR). *Clinical classes between DVR and No DVR groups with a significantly different distribution statistically at each encounter.