Efficacy of Minimally Invasive Vascular Interventions Assessed with Mobile Multispectral Near-infrared Spectroscopy

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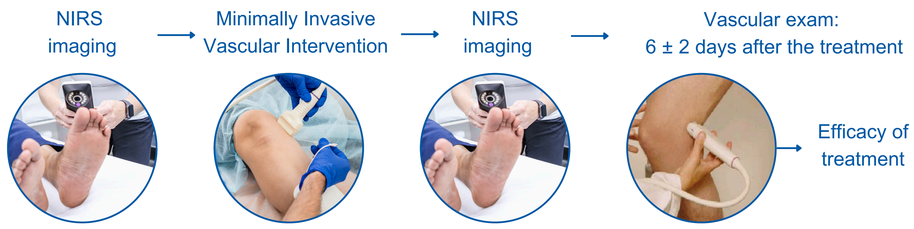
Introduction

Chronic venous insufficiency (CVI) is one of the most prevalent diseases in the world.[1] Several interventional options are available for patients with CVI, including sclerotherapy, endovenous laser treatment, radiofrequency ablation (RFA), and surgical ligation and stripping.[2] The use of minimally invasive techniques like foam sclerotherapy and RFA has increased significantly in recent years.[3–4] While duplex ultrasonography (DUS) remains the gold standard for diagnosing venous insufficiency and evaluating treatment efficacy, it is time-consuming and resource-intensive.[5] Near-infrared spectroscopy (NIRS) imaging, a non-invasive modality, offers spatial information on tissue oxygenation (StO_2) and has the potential to streamline evaluations. By measuring changes in tissue oxygenation pre- and post-treatment, this study aims to provide insights into the utility of NIRS imaging as a non-invasive tool for assessing treatment outcomes.

Study design

This quasi-experimental pre-posttest study included 14 CVI patients treated with foam sclerotherapy or RFA between November 2022 and February 2024. All had significant great saphenous vein insufficiency with normal deep venous pathology, except one case with partial chronic deep vein thrombosis. NIRS images were collected before and immediately after treatment from various anatomical sites, including the foot (dorsum, plantar), leg (medial, lateral), and wound area if present. Tissue oxygenation was measured using an FDA-cleared handheld multispectral NIRS imaging device (MIMOSA Pro, MIMOSA Diagnostics Inc., Toronto, Canada).



Demographic and Clinical Characteristics of Study Participants

Detail	n, (%)		
Age, years	70 +/- 12		
Gender	Male: 11, (79 %)	Female: 3, (21%)	
Body mass index (BMI)	31 +/- 7		
Preoperative CEAP*	CEAP = 4: 3, (21%)	CEAP = 5: 4, (29%)	CEAP = 6: 7, (50%)
Fitzpatrick Score (FS)	FS=1: 8, (57%)	FS=[2, 3]: 3, (21%)	FS> 3: 3, (21%)
VCSS total score	Moderate (6-10): 2, (14%)	Severe (11-20): 12, (86%)	
VLU	No: 7, (50%)	Active: 7, (50%)	

*CEAP classification: Clinical (C), Etiological (E), Anatomical (A), and Pathophysiological (P)
VCSS: The Venous Clinical Severity Score
VLU: venous leg ulcer

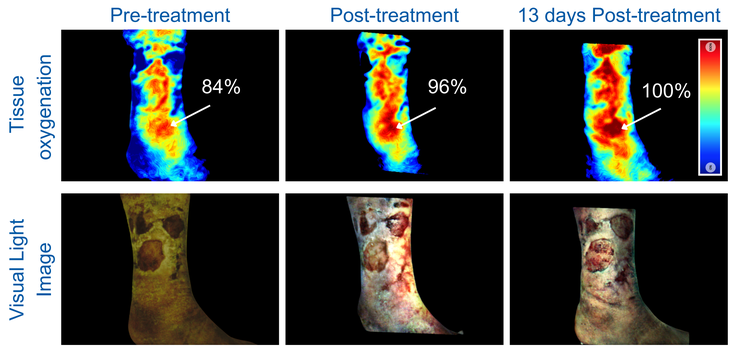
Procedure Location and Type

Procedure location	
Right GSV	8, (57%)
Left GSV	6, (43%)
Procedure type	
Treatment of main trunk (GSV, AASV, SSV)	
Polidocanol injectable foam sclerotherapy	3, (21%)
Radiofrequency ablation	10, (71%)
Treatment of tributaries	
Polidocanol injectable foam sclerotherapy	1, (7%)

*GSV: great saphenous vein; AASV: Anterior accessory saphenous vein; SSV: Small Saphenous Vein

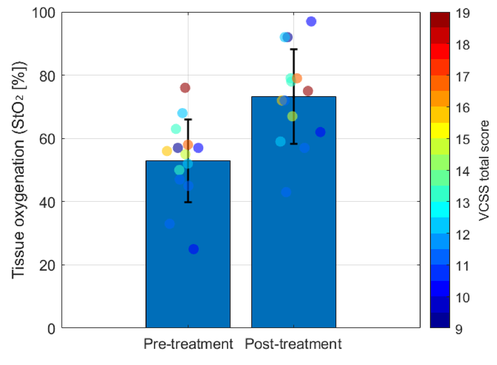
Results

Case Example (12): 74-year-old male with a BMI of 27.37 and a history of Type 2 diabetes. Pre-treatment, the patient presented with an active circumferential venous ulcer on the left lower extremity. There was no evidence of acute DVT bilaterally. Previous DVT was noted with chronic scarring in both the deep and superficial veins of the left lower extremity, along with wall thickening and partially occlusive chronic thrombus in the left GSV and lesser saphenous vein. Venous reflux was present in both the deep and superficial venous systems.

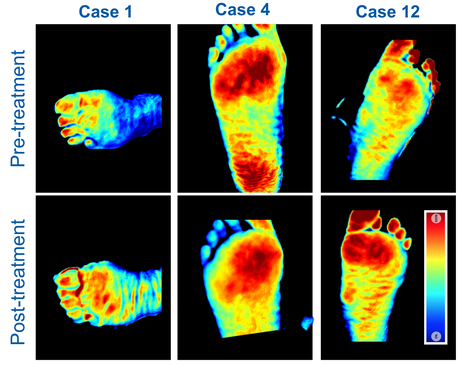


While the results observed 13 days post-treatment show a more significant increase compared to the immediate response, the immediate improvement still highlights the effectiveness of the treatment and the utility of NIRS.

Successful vein closure after RFA and sclerotherapy was confirmed in all 14 cases (100%) using postoperative DUS, with no reopening observed during the follow-up period. Post-treatment NIRS data showed an average 20% increase in mean StO_2 on the plantar surface for 13 cases (93%), while one case (7%) showed no clinically significant change. Before treatment, the mean StO_2 was 53%. After treatment, the mean StO_2 on the treatment side increased to 73%, representing a statistically significant improvement ($p < 0.05$).



The plot illustrates the mean tissue oxygenation across the plantar foot for pre-treatment and post-treatment data from all 14 cases. The bars represent the mean values, while error bars indicate the standard deviation. Individual data points are represented as circles, with their color reflecting the corresponding VCSS total score.



Case examples of tissue oxygenation images before and after treatment. Top: pre-treatment, Bottom: post-treatment. Plantar foot views.

Discussion & Conclusion

Near-infrared spectroscopy imaging provides a reliable, non-invasive method for real-time monitoring of tissue oxygenation. By visualizing microcirculation changes, NIRS enables clinicians to detect treatment success or failure earlier, facilitating timely interventions. While the small sample size limits generalizability, these findings highlight the potential of NIRS imaging as a valuable clinical tool for optimizing vascular treatment outcomes. Future research with larger cohorts is recommended to validate these results.

Bibliography

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