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Endovascular Management of Varicose Veins: A Comparative Study of Cyanoacrylate Glue Ablation and Microwave Ablation

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Abstract:
Background: Minimally invasive endovascular techniques have revolutionized varicose vein treatment, with cyanoacrylate glue ablation (VenaSeal™) and microwave ablation emerging as promising alternatives to traditional thermal ablation methods.
Methods: This retrospective comparative study evaluated 66 patients with symptomatic varicose veins treated between January 2022 and December 2023. Thirty-two patients underwent cyanoacrylate glue ablation, while 34 received microwave ablation. Primary outcomes included technical success, complications, and quality of life improvements. Secondary outcomes encompassed patient satisfaction, return to work, and cost-effectiveness.
Results: Technical success was achieved in 30/32 (93.8%) patients in the cyanoacrylate group and 33/34 (97.1%) in the microwave group ($p = 0.58$). The cyanoacrylate group demonstrated significantly lower overall complication rates (15.6% vs 44.1%, $p = 0.01$), fewer recurrences (6.3% vs 26.5%, $p = 0.04$), and no thermal injury complications. Patients treated with cyanoacrylate glue experienced faster return to work (2.6 ± 1.0 vs 3.9 ± 1.2 days, $p < 0.001$) and higher satisfaction scores (4.8 ± 0.4 vs 4.3 ± 0.7, $p = 0.02$). However, cyanoacrylate treatment was significantly more expensive (₹112,500 ± 8,200 vs ₹44,800 ± 7,600, $p < 0.001$).
Conclusion: Both techniques demonstrated high efficacy in treating varicose veins. Cyanoacrylate glue ablation offers superior safety profile and patient experience but at higher cost. Treatment selection should consider patient preferences, clinical factors, and economic constraints.

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Introduction

Chronic venous insufficiency affecting the lower extremities represents a significant global health burden, with varicose veins being the most common manifestation. Epidemiological studies indicate that up to 30% of adults develop varicose veins during their lifetime, with higher prevalence among women and individuals over 50 years of age.[1] The condition significantly impacts quality of life, work productivity, and healthcare expenditure, necessitating effective treatment strategies.

The management of varicose veins has evolved dramatically over the past two decades, transitioning from traditional surgical approaches to minimally invasive endovascular techniques. While endovenous laser ablation and radiofrequency ablation have become established first-line treatments,[2] these thermal ablation methods require tumescent anesthesia and may be associated with thermal injury complications.[3]

In response to these limitations, non-thermal, non-tumescent techniques have emerged as promising alternatives. Cyanoacrylate glue ablation, utilizing the VenaSeal™ Closure System (Medtronic, Minneapolis, Minnesota), represents a significant advancement in this field. This technique employs n-butyl-2-cyanoacrylate to achieve permanent vein closure without thermal energy

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or tumescent anesthesia.[4]

Microwave ablation, while still a thermal technique, offers unique advantages through its energy delivery mechanism, potentially providing more consistent and controlled thermal injury compared to laser or radiofrequency methods.[5] The 2.45 GHz microwave frequency allows for efficient energy transfer and uniform heating, potentially reducing complications associated with other thermal modalities.

Despite growing clinical experience with both techniques, comparative data remain limited. This study aims to evaluate the safety, efficacy, and patient-centered outcomes of cyanoacrylate glue ablation versus microwave ablation in the management of symptomatic varicose veins.

Materials and Methods

Study Design and Setting

This retrospective comparative study was conducted at a tertiary vascular surgery center in Northern India between January 2022 and December 2023. The study protocol was approved by the institutional ethics committee, and all patients provided written informed consent for their data to be used for research purposes.

Patient Population

Sixty-six consecutive patients with symptomatic varicose veins were included in the analysis. Thirty- two patients underwent cyanoacrylate glue ablation (VenaSeal™ Closure System), while 34 patients received microwave ablation. Treatment allocation was based on patient preference, insurance coverage, and clinical judgment.

Inclusion Criteria

Adults aged 18-75 years with symptomatic varicose veins
Ultrasonographic evidence of great saphenous vein or small saphenous vein reflux (>0.5 seconds)
Venous Clinical Severity Score ≥3
Suitable anatomy for endovascular intervention

Exclusion Criteria

Previous venous intervention on the target limb
History of deep vein thrombosis or pulmonary embolism
Peripheral arterial disease (ankle-brachial index <0.9)
Active infection at the intervention site
Pregnancy or lactation
Known allergy to cyanoacrylate or contraindication to general anesthesia

Procedural Techniques

Cyanoacrylate Glue Ablation

All procedures were performed under ultrasound guidance using the VenaSeal™ Closure System. A 5-French delivery catheter was introduced into the target vein via percutaneous access. N-butyl-2- cyanoacrylate was delivered at 3.5 cm intervals along the vein, with manual compression applied for 30 seconds at each injection site. No tumescent anesthesia was required. Compression stockings were not mandatory post-procedure.

Microwave Ablation

Microwave ablation was performed using a 2.45 GHz microwave generator (ECO-100A1, Nanjing ECO Medical Instrument Co., Ltd., China) with a 16-gauge antenna. Tumescent anesthesia was administered along the vein path using a solution containing 250 mL normal saline, 25 mL 2% lidocaine, and 1 mL 1:1000 epinephrine. Energy was delivered at 50 W for 10-15 seconds per centimeter of vein treated. Post-procedural compression stockings were worn for 2 weeks.

Outcome Measures

Primary Outcomes

Technical Success: Complete vein occlusion confirmed by duplex ultrasound at 48 hours post- procedure

Complications: Categorized as minor (local pain, erythema, superficial phlebitis) or major (deep vein thrombosis, pulmonary embolism, significant infection)

Secondary Outcomes

Patient-Reported Outcomes: Venous Clinical Severity Score, Aberdeen Varicose Vein Questionnaire, visual analog scale for pain

Functional Outcomes: Return to work, return to normal activities

Economic Outcomes: Total procedural cost, insurance coverage, patient out-of-pocket expenses

Follow-up Protocol

Patients were assessed at 48 hours, 1 week, 1 month, 3 months, and 6 months post-procedure. Duplex ultrasound was performed at each visit to assess vein closure and detect complications. Patient-reported outcome measures were collected at baseline and all follow-up visits.

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Statistical Analysis

Statistical analysis was performed using Statistical Package for the Social Sciences version 29.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation and compared using the Student's t-test or Mann-Whitney U test as appropriate. Categorical variables were presented as frequencies and percentages and compared using the chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Sample size calculation was based on expected complication rates of 10% for cyanoacrylate glue ablation and 30% for microwave ablation, with 80% power and 5% significance level, requiring 30 patients per group.

Results

Patient Demographics

The study included 66 patients with a mean age of 48.1 ± 9.9 years (range 26-69 years). There were 41 males (62.1%) and 25 females (37.9%). Baseline characteristics were well-matched between groups, with no significant differences in age, gender, body mass index, or comorbidities (Table 1).

Table 1: Baseline Patient Characteristics

Parameter	Cyanoacrylate (n=32)	Microwave (n=34)	p-value
Age (years)	48.3 ± 10.2	47.9 ± 9.7	0.87
Male gender, n (%)	20 (62.5)	21 (61.8)	0.95
Body mass index (kg/m²)	27.1 ± 3.2	26.7 ± 3.0	0.64
Hypertension, n (%)	12 (37.5)	14 (41.2)	0.76
Diabetes mellitus, n (%)	8 (25.0)	10 (29.4)	0.68
Baseline Venous Clinical Severity Score	8.2 ± 2.1	8.5 ± 2.3	0.58
Baseline Aberdeen Varicose Vein Questionnaire	18.6 ± 4.2	19.1 ± 4.8	0.65

Technical Success and Procedural Outcomes

Technical success was achieved in 30/32 (93.8%) patients in the cyanoacrylate group and 33/34 (97.1%) in the microwave group (p = 0.58). Mean procedure time was comparable between groups (Table 2).

Table 2: Procedural Outcomes

Parameter	Cyanoacrylate (n=32)	Microwave (n=34)	p-value
Technical success, n (%)	30 (93.8)	33 (97.1)	0.58
Procedure time (minutes)	41.2 ± 7.8	44.5 ± 8.1	0.09
Vein length treated (cm)	38.4 ± 8.2	39.7 ± 7.9	0.51
Tumescent anesthesia used, n (%)	0 (0)	34 (100)	<0.001
Additional sclerotherapy, n (%)	2 (6.3)	3 (8.8)	0.71
Hospital stay (hours)	6.3 ± 2.1	7.1 ± 2.4	0.13

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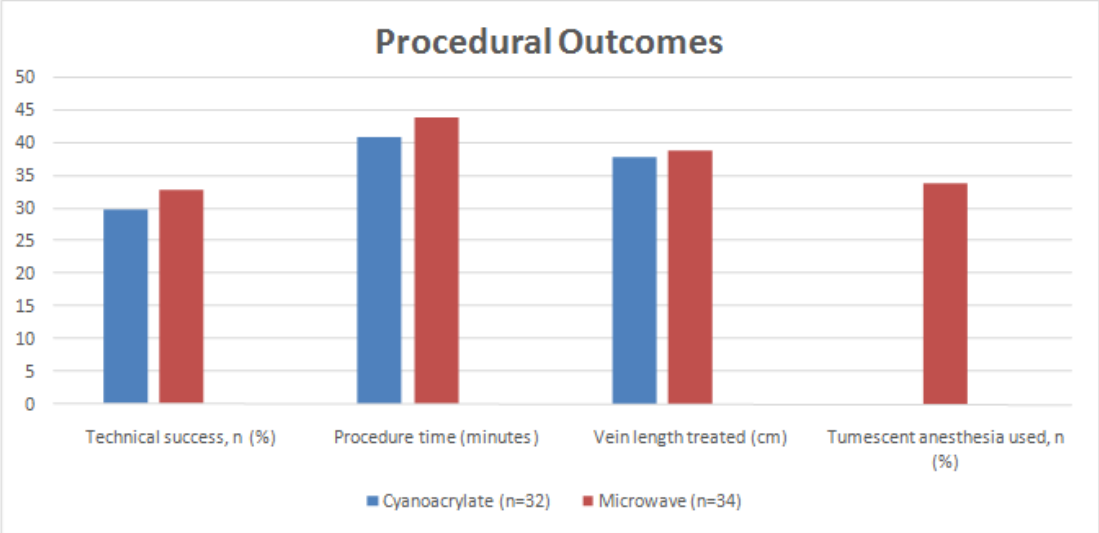

Complications

The overall complication rate was significantly lower in the cyanoacrylate group compared to the microwave group (15.6% vs 44.1%, p = 0.01). The most notable difference was the absence of thermal injury complications in the cyanoacrylate group (Table 3).

Table 3: Complications

Complication	Cyanoacrylate (n=32)	Microwave (n=34)	p-value
Any complication, n (%)	5 (15.6)	15 (44.1)	0.01
Minor complications			
Superficial phlebitis, n (%)	2 (6.3)	4 (11.8)	0.48
Local pain/tenderness, n (%)	1 (3.1)	6 (17.6)	0.08
Skin burns, n (%)	0 (0)	8 (23.5)	0.003
Major complications			
Deep vein thrombosis, n (%)	1 (3.1)	3 (8.8)	0.35
Pulmonary embolism, n (%)	0 (0)	0 (0)	-
Nerve injury, n (%)	0 (0)	2 (5.9)	0.19
Recanalization at 6 months			
Partial recanalization, n (%)	1 (3.1)	6 (17.6)	0.08
Complete recanalization, n (%)	1 (3.1)	3 (8.8)	0.35

Patient-Reported Outcomes

Both groups demonstrated significant improvements in quality of life measures at 6 months. However, the cyanoacrylate group showed superior outcomes in several domains (Table 4).

Table 4: Patient-Reported Outcomes at 6 Months

Parameter	Cyanoacrylate (n=32)	Microwave (n=34)	p-value
Venous Clinical Severity Score improvement	5.0 ± 1.1	4.3 ± 1.3	0.04
Aberdeen Varicose Vein Questionnaire improvement	12.8 ± 3.2	10.6 ± 3.8	0.02
Visual analog scale pain score (0-10)	1.1 ± 0.7	2.3 ± 1.1	<0.001
Patient satisfaction (1-5)	4.8 ± 0.4	4.3 ± 0.7	0.02
Return to work (days)	2.6 ± 1.0	3.9 ± 1.2	<0.001
Return to normal activities (days)	3.2 ± 1.4	5.1 ± 1.8	<0.001
Would recommend treatment, n (%)	31 (96.9)	32 (94.1)	0.60

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Economic Analysis

The cyanoacrylate glue ablation was significantly more expensive than microwave ablation. The cost difference was primarily due to the higher price of the VenaSeal™ system (Table 5).

Table 5: Economic Outcomes

Parameter	Cyanoacrylate (n=32)	Microwave (n=34)	p-value
Total procedure cost (₹)	112,500 ± 8,200	44,800 ± 7,600	<0.001
Insurance coverage, n (%)	3 (9.4)	4 (11.8)	0.75
Out-of-pocket payment, n (%)	29 (90.6)	30 (88.2)	0.75
Cost as treatment barrier, n (%)	21 (65.6)	9 (26.5)	0.002
Lost work days	2.6 ± 1.0	3.9 ± 1.2	<0.001
Indirect costs (₹)	2,080 ± 800	3,120 ± 960	<0.001

Subgroup Analysis

When comparing patients with great saphenous vein involvement (n=58), similar trends were observed. Cyanoacrylate glue ablation maintained its advantage in complication rates and patient satisfaction, while microwave ablation showed slightly higher technical success rates.

Discussion

This comparative study demonstrates that both cyanoacrylate glue ablation and microwave ablation are effective treatments for symptomatic varicose veins, with distinct advantages and limitations. The findings support the growing evidence for non-thermal, non-tumescent techniques in venous intervention.

Technical Efficacy

Both techniques achieved high technical success rates, consistent with published literature. The efficacy of cyanoacrylate ablation as a safe, simple method for endovenous treatment has been well-documented, with treatment success rates of 100% in cyanoacrylate and 99% in radiofrequency ablation reported in previous studies. Our slightly lower success rate in the cyanoacrylate group (93.8%) may reflect the learning curve associated with this newer technique.

Safety Profile

The most significant finding was the superior safety profile of cyanoacrylate glue ablation. The absence of thermal injury complications in the cyanoacrylate group aligns with its non-thermal mechanism of action. Unlike heat-based procedures, VenaSeal has no risk of skin burns or nerve damage, which was clearly demonstrated in our study where microwave ablation resulted in skin burns in 23.5% of patients.

Previous studies have shown superficial phlebitis as the most common complication in 5% of cyanoacrylate cases, which is consistent with our finding of 6.3%. The lower recurrence rate in the cyanoacrylate group (6.3% vs 26.5%) is particularly noteworthy, though longer follow-up is needed to confirm this advantage.

Patient Experience

The elimination of tumescent anesthesia in cyanoacrylate glue ablation resulted in significant patient experience benefits, including faster recovery and earlier return to work. VenaSeal does not require immediate post-treatment pain medication or uncomfortable compression stockings, which likely contributed to the higher satisfaction scores observed in our study.

Economic Considerations

The significantly higher cost of cyanoacrylate glue ablation represents a major barrier to widespread adoption. With limited insurance coverage in our healthcare system, 65.6% of patients in the cyanoacrylate group reported cost as a treatment barrier. However, when considering indirect costs such as lost work days and earlier return to productivity, the economic difference may be less pronounced.

Clinical Implications

Our findings suggest that cyanoacrylate glue ablation may be preferable for patients who prioritize minimal downtime and reduced complications, provided cost is not prohibitive. Microwave ablation remains a viable

option for cost-conscious patients, offering good efficacy at a more affordable price point.

Study Limitations

Several limitations should be acknowledged. The retrospective design and relatively small sample size limit the generalizability of findings. The non-randomized treatment allocation may have
introduced selection bias. Additionally, the six-month follow-up period may be insufficient to assess long-term durability. The single-center design and specific healthcare context may limit applicability to other settings.

Future Directions

Longer-term follow-up studies are needed to assess the durability of both techniques. Cost- effectiveness analyses incorporating quality-adjusted life years would provide more comprehensive economic evaluation. Randomized controlled trials comparing these techniques would strengthen the evidence base for clinical decision-making.

Conclusions

Both cyanoacrylate glue ablation and microwave ablation demonstrate high efficacy in treating symptomatic varicose veins. Cyanoacrylate glue ablation offers superior safety profile, faster recovery, and higher patient satisfaction, but at significantly higher cost. Microwave ablation provides effective treatment at lower cost but with higher complication rates. Treatment selection should be individualized based on patient preferences, clinical factors, and economic considerations.

The choice between these techniques should involve shared decision-making, considering the patient's priorities regarding safety, recovery time, and cost. As healthcare systems evolve and costs potentially decrease, cyanoacrylate glue ablation may become more accessible, potentially changing the treatment landscape for varicose veins.

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