Laser ablation versus mechanochemical ablation in the treatment of primary varicose veins: A randomized clinical trial

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ABSTRACT

Objective: to prospectively compare the surgical outcome of using endovenous laser ablation (EVLA) and mechanochemical ablation (MOCA) in management of patients with primary varicose veins (VV).

Methods: The present study prospectively recruited 100 patients with primary VV. They were randomly and equally allocated to one of two treatment group: the EVLA group (n = 50) or the MOCA group (n = 50). Before intervention, all patients underwent to clinical and ultrasound assessment of the vascular system. The Venous Clinical Severity Score was used to assess clinical severity. In addition, patients completed the Chronic Venous Insufficiency Questionnaire. The primary study outcome was treatment success. After intervention, patients were followed up at 1 week, 1 months, 6 months, and 12 months.

Results: Operative success was achieved in all patients. The MOCA group had a significantly shorter operative time when compared with EVLA group. The Venous Clinical Severity Score significantly improved in both groups over the follow-up period and showed significantly lower levels in the MOCA group. Perceived pain was significantly improved in both groups postoperatively with no significant differences. The Chronic Venous Insufficiency Questionnaire was significantly improved after 12 months of operation without significant differences between groups. MOCA patients had significantly lower rate of postoperative phlebitis and significantly shorter time to return to work.

Conclusions: MOCA for primary VV is a feasible, effective, and safe procedure with better clinical outcome and lower rate of postoperative phlebitis when compared with EVLA. (J Vasc Surg: Venous and Lym Dis 2019;■:1-5.)

Keywords: Varicose veins; Endovenous laser ablation; Mechanochemical laser ablation

Varicose veins (VV) are one of the commonest morbidities affecting the vascular system. Although the exact pathogenesis of the condition is not fully understood, contributing mechanisms involve hypoxic changes, altered extracellular matrix, and disorganized apoptosis.[1] Failure to properly manage VV may cause troublesome complications such as venous ulceration and thrombosis.[2]

Management encompasses multiple options with variable cost and outcomes. Nowadays, minimally invasive endothermal procedures have replaced the traditional techniques of surgical ligation and stripping.[3,4] Among these procedures, endovenous laser ablation (EVLA) proved to be safe and effective technique despite some reports associating the procedure with high risk of 12-month recurrence.[5]

However, the recent emergence of newer, nontumescent techniques offers more promising alternatives. These techniques advantageously avoid the hazards of tumescent anesthesia together with being cost effective as shown by initial studies.[6] One of these techniques is endovenous mechanochemical ablation (MOCA). It proved to be comparable—if not superior—to endothermal techniques in terms of technical feasibility, operative efficacy and procedural safety.[7]

Unfortunately, studies that compare MOCA with EVLA are lacking. Thus, the present study sought to prospectively compare the surgical outcome of using these techniques in management of patients with VV.

METHODS

Study design and setting. This randomized clinical study was conducted at Zagazig University Hospitals, Zagazig, Egypt, from January 2017 through October 2018. The study protocol was approved by the local ethical committee in accordance with the Declaration of Helsinki on medical research involving human subjects. Before enrollment, all participants gave informed consent.

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Patient recruitment. Patients were included in the study if they had primary great saphenous vein incompetence with or without incompetent perforators based on color duplex ultrasound examination and C2 to C4 VV according to the Clinical, Etiologic, Anatomic, Pathophysiologic classification.[8] Exclusion criteria were pregnancy; a history of superficial thrombophlebitis, deep venous thrombosis, or pulmonary embolism; venous ulcers (healed or active); severe medical illness (cardiac, hepatic, renal, cancer, or bleeding disorders patients); recurrent VV; anticoagulant therapy; peripheral arterial diseases or vasculitis; or and internal pacemaker.

Randomization and blinding. Among the 123 patients screened for participation in the study, 100 eligible patients were allocated to one of the treatment arms using equal computerized randomization and sealed envelope technique. Although blinding of the patients and clinical team was not possible owing to the nature of interventions, we managed to minimize probable bias by recruiting preoperative and postoperative assessors who were not aware of the available treatment options.

Preoperative assessment. Before the intervention, patient evaluation was completed by a skilled surgeon who was not aware of the type of intervention. Evaluation included careful history taking and thorough clinical examination. Vascular system assessment was performed using color duplex ultrasound (GE Logic 3 and GE logic 5 Ultrasound System, GE Medical System, Milwaukee, Wisc) to determine the diameter of the GSV and the extent of venous insufficiency. For deep venous thrombosis prophylaxis, we used a single dose of enoxaparin (20 or 40 mg according to patient's weight) just before the procedure. The Venous Clinical Severity Score (VCSS) was used to assess clinical severity.[9] In addition, patients completed the Chronic Venous Insufficiency Questionnaire (CIVIQ).[10]

Study interventions. Patients allocated to EVLA group (n = 50) underwent EVLA. The procedure was performed under tumescent anesthesia with patients in reverse Trendelenburg position by means of 1470-nm diode laser, radial fiber under ultrasound guidance (Biolitec AG, Jena, Germany). A 6F sheath was introduced for guiding the fiber. Laser fiber was inserted until the distal tip was positioned 1.5 cm below the saphenofemoral junction. Continuous pullback was used while the user watches the real-time energy readout on the generator and gauges speed with the 1-cm marks on the sheath delivering 80 to 120 J/cm according to vein diameter. Complementary percutaneous ultrasound-guided foam injection sclerotherapy using polidocanol (Aethoxysklerol 2%) (Kreussler Pharma, Wiesbaden, Germany) was used to treat incompetent perforating veins and superficial varicosities.[11]

In contrast, the MOCA group patients (n = 50) were submitted to MOCA using Flebogrif, (Balton, Poland) (Fig). The Flebogrif system is new device used for MOCA. It depends on the maximum diameter of the hooks when opened to produce the mechanical effects on the venous wall.[12]

Under local anesthesia with patients in the reverse Trendelenburg position, a 4F to 5F sheath was inserted. Through this sheath, the Flebogrif infusion catheter was placed. Injection of the sclerosing agent was started simultaneously with catheter pullback at a rate of 1 mL/5 cm.[13]

In all patients, we ablated small saphenous veins and straight accessory saphenous veins or used foam injections for severely tortuous anterior saphenous vein, superficial varicosities, and below knee segments.

All procedures were performed by the same surgical team, which has adequate experience with endovenous procedures.

Postoperative assessment, study outcomes, and follow-up. The primary study outcome was treatment success defined as complete occlusion of the affected

ARTICLE HIGHLIGHTS

- **Type of Research:** Randomized controlled trial
- **Key Findings:** One hundred patients with varicose veins were randomized to laser and mechanochemical ablation (MOCA) and had comparable procedural success rates and both procedures resulted in significant clinical improvement at 12 months. MOCA was associated with better Venous Clinical Severity Score, less frequency of phlebitis, and shorter time to return to work.
- **Take Home Message:** MOCA is a feasible, effective, and safe procedure for the management of varicose veins.

Fig. Duplex ultrasound image shows the saphenofemoral junction with the catheter positioned and hook opened (*arrow*).

Table I. Comparison between the studied groups regarding the preoperative data

	EVLA (n = 50)	MOCA (n = 50)	*P* value
Age, years	33.1 ± 9.5	34.1 ± 10.4	.63
Sex, male/female	14/36	17/33	.52
BMI, kg/m^2	21.9 ± 1.9	21.6 ± 1.0	.23
Affected side, right/left	21/29	27/23	.89
Affected veins			
GSV	50 (100.0)	50 (100.0)	–
SSV	2 (4.0)	5 (10.0)	.24
Extra-axial varicosities	27 (42.0)	32 (64.0)	.23
Incompetent perforator	41 (82.0)	44 (88.0)	.4
Superficial accessory saphenous	5 (10.0)	–	.022
CEAP classification, C3/C4	(13/37)	(16/34)	.51
GSV diameter, mm	10.4 ± 2.9	11.3 ± 3.9	.19

BMI, Body mass index; *CEAP classification,* Clinical, Etiologic, Anatomic, Pathophysiologic classification; *EVLA,* endovenous laser ablation; *GSV,* great saphenous vein; *MOCA,* mechanochemical ablation; *SSV,* small saphenous vein.
Values are mean ± standard deviation or number (%).

Table II. Reported outcomes

	EVLA (n = 50)	MOCA (n = 50)	*P* value
Operative time, minutes	46.9 ± 10.0	29.6 ± 9.0	<.001
Preoperative VCSS	11.5 ± 1.2	11.0 ± 1.3	.08
Postoperative VCSS at 1 week	7.3 ± 1.0	6.5 ± 0.7	<.001
Postoperative VCSS at 1 month	6.0 ± 0.9	4.6 ± 0.9	<.001
Postoperative VCSS at 6 months	4.4 ± 1.0	3.2 ± 0.8	<.001
Postoperative VCSS at 12 months	2.8 ± 0.8	2.3 ± 0.5	<.001
P value	<.001	<.001	
Preoperative pain	7.2 ± 0.9	7.4 ± 0.8	.14
Postoperative pain at 1 week	2.1 ± 1.0	2.4 ± 0.7	.09
Postoperative pain at 1 month	1.1 ± 0.8	1.3 ± 0.9	.29
Postoperative pain at 6 months	0.5 ± 0.7	0.4 ± 0.6	.6
Postoperative pain at 12 months	0.2 ± 0.5	0.2 ± 0.5	1.0
P value	<.001	<.001	
Preoperative CIVIQ	54.6 ± 9.0	55.8 ± 5.1	.4
Postoperative CIVIQ at 12 months	16.2 ± 6.5	16.1 ± 2.1	.93
P value	<.001	<.001	
Complications			
Phlebitis	7 (14.0)	–	.006
Bruising	2 (4.0)	1 (2.0)	.56
Hematoma	–	–	–
Return to work, days	8.0 ± 1.4	3.8 ± 1.0	<.001
Short-term recurrence	1 (2.0)	2 (4.0)	.56

CIVIQ, Chronic Venous Insufficiency Questionnaire; *EVLA,* endovenous laser ablation; *MOCA,* mechanochemical ablation; *VCSS,* Venous Clinical Severity Score.
Values are mean ± standard deviation or number (%).

vein segment assessed by duplex ultrasound examination. Secondary outcomes included operative time, and postoperative complications. Postoperative phlebitis was defined as the presence of the four cardinal symptoms and signs of inflammation (pain, redness, edema, and tenderness) along the anatomic course of the vein. Other assessed parameters included postoperative pain using standard 10-cm visual analog scale, VCSS, CIVIQ, and time needed to return to work. Patients were instructed to return to work as early as the third postoperative day. Postoperative assessment was performed at the intervals of 1 week, 1 month, 6 months, and 12 months. All patients showed appropriate adherence to postintervention follow-up.

Statistical analysis. Data obtained from the present study were statistically analyzed using SPSS 22 (IBM, Armonk, NY). Categorical variables were presented as number and percentage while numerical variables were presented as mean ± standard deviation. Comparative analysis was achieved using Fisher exact test, χ^2 test, *t*-test, or paired *t*-test as appropriate. Repeated measurements were evaluated using repeated measures analysis. A *P* value of less than .05 was considered statistically significant.

RESULTS

Comparison between the studied groups regarding the preoperative data showed no statistically significant differences. The only exception the significantly higher frequency of superficial accessory saphenous veins in EVLA group (Table I).

The outcome parameters of the studied groups are illustrated in Table II. Operative success was achieved in all patients. MOCA group had significantly shorter operative time when compared with EVLA group (29.6 ± 9.0 minutes vs 46.9 ± 10.0 minutes; $P < .001$). Although the VCSS significantly improved in both groups over the follow-up period, it showed significantly lower levels in the MOCA group. Perceived pain was significantly improved in both groups postoperatively with no significant differences. Likewise, the CIVIQ was significantly improved after 12 months of operation without significant differences between groups. In addition, it was noted that MOCA patients had a significantly lower rate

of postoperative phlebitis and significantly shorter time to return to work. None of the studied patients experienced endovenous heat-induced thrombosis, deep venous thrombosis, or pulmonary embolism.

DISCUSSION

This randomized study was conducted to compare the outcome of EVLA and MOCA in treatment of primary VV. Despite results were comparable regarding the rate of short-term recurrence, MOCA was associated with significantly lower rates of postoperative phlebitis. Moreover, patients subjected to MOCA needed significantly fewer days to return to work in comparison to their counterparts treated using EVLA.

Patients in the first treatment arm, however, had good outcomes in terms of treatment success and a low rate of postoperative complications and recurrence, which is consistent with previous studies. In a large study involving 236 patients (355 limbs), EVLA using bare-tipped 1470-nm laser resulted in a 100% technical success rate. Treatment effect was sustained in 100.0%, 99.5%, and 99.3% after 1 week, 1 month, and 3 months, respectively. However, considerable rate of complications was reported including bruising (21%), pain (15%), and paresthesia (4%).[14] Similar conclusions were documented by other studies using different laser wavelengths or energy settings, on patients with variable clinical characteristics.[15-21]

The excellent safety profile and treatment success of MOCA procedure reported by the present study is supported by findings of other published reports. In the early studies of van Eekeren et al[13] and Elias and Raines,[22] the primary closure rate was 100.0% and 96.7%, respectively, with minor or no side effects. Subsequent studies confirmed these impressions including the multicentric studies of Bishawi et al[23] and Bootun et al,[24] who highlighted the minimal pain associated with the procedure. Moreover, the 2-year follow-up study of Kim et al[25] concluded that the high initial occlusion rate of MOCA was maintained at 24 months.

The significantly lower VCSS and phlebitis rates in MOCA group reported by the present study may be expected in view of the mechanism by which MOCA produces its clinical effects. The technique uses hybrid or dual injury mechanism that combines mechanical destruction to the endothelium by the tip of the rotating catheter wire with chemical endovenous ablation by the injected sclerosing agent, thereby avoiding the drawbacks of thermal endovenous ablation.[26] The animal study of Tal et al[27] provided histologic evidence supporting MOCA use in clinical practice. Histologic staining of the treated veins revealed total fibrotic sealing with extensive collagen production in all veins. Moreover, it was shown that the mechanical destruction of the vascular endothelium facilitates better penetration of the sclerosing agent when compared with sclerosing agent injection alone.[28]

CONCLUSIONS

This study suggests that MOCA for primary VV has considerable advantages over EVLA. Besides its convenient technical feasibility, it provides better clinical improvement, less frequency of postoperative complications, and shorter time to return to normal activities.

Still, this study has its limitations. The sample size was chosen arbitrarily and therefore the study may be underpowered to detect some statistically or clinically relevant endpoints. Also, the reported follow-up time is limited to 1 year.

AUTHOR CONTRIBUTIONS

Conception and design: AT, MEL
Analysis and interpretation: AT, WS
Data collection: WS, MEL
Writing the article: AT, WS
Critical revision of the article: AT, MEL
Final approval of the article: AT, WS, MEL
Statistical analysis: WS, MEL
Obtained funding: AT
Overall responsibility: AT

REFERENCES

1. Jacobs BN, Andraska EA, Obi AT, Wakefield TW. Pathophysiology of varicose veins. J Vasc Surg Venous Lymphat Disord 2017;5:460-7.
2. Chwala M, Szczeklik W, Szczeklik M, Aleksiejew-Kleszczynski T, Jagielska-Chwala M. Varicose veins of lower extremities, hemodynamics and treatment methods. Adv Clin Exp Med 2015;24:5-14.
3. Lin F, Zhang S, Sun Y, Ren S, Liu P. The management of varicose veins. Int Surg 2015;100:185-9.
4. Epstein D, Onida S, Bootun R, Ortega-Ortega M, Davies AH. Cost-effectiveness of current and emerging treatments of varicose veins. Value Health 2018;21:911-20.
5. Lynch NP, Clarke M, Fulton GJ. Surgical management of great saphenous vein varicose veins: a meta-analysis. Vascular 2015;23:285-96.
6. Kolluri R. Interventions for varicose veins: beyond ablation. Curr Treat Options Cardiovasc Med 2016;18:43.
7. Witte ME, Reijnen MM, de Vries JP, Zeebregts CJ. Mechanochemical endovenous occlusion of varicose veins using the ClariVein(R) device. Surg Technol Int 2015;26:219-25.
8. Kistner RL, Eklof B, Masuda EM. Diagnosis of chronic venous disease of the lower extremities: the "CEAP" classification. Mayo Clin Proc 1996;71:338-45.
9. Vasquez MA, Wang J, Mahathanaruk M, Buczkowski G, Sprehe E, Dosluoglu HH. The utility of the Venous Clinical Severity Score in 682 limbs treated by radiofrequency saphenous vein ablation. J Vasc Surg 2007;45:1008-14; discussion: 1015.
10. Launois R, Reboul-Marty J, Henry B. Construction and validation of a quality of life questionnaire in chronic lower limb venous insufficiency (CIVIQ). Qual Life Res 1996;5:539-54.
11. Johnson CM, McLafferty RB. Endovenous laser ablation of varicose veins: review of current technologies and clinical outcome. Vascular 2007;15:250-4.

12. Jindal R, Verma D, Kaur T, Dhillon S, Kaur N, Chaudhary P. Mechanochemical endovenous ablation: latest varicose vein treatment. Indian J Vasc Endovas Surg 2019;6:44.
13. van Eekeren RR, Boersma D, Elias S, Holewijn S, Werson DA, de Vries JP, et al. Endovenous mechanochemical ablation of great saphenous vein incompetence using the ClariVein device: a safety study. J Endovasc Ther 2011;18:328-34.
14. Park JA, Park SW, Chang IS, Hwang JJ, Lee SA, Kim JS, et al. The 1,470-nm bare-fiber diode laser ablation of the great saphenous vein and small saphenous vein at 1-year follow-up using 8-12 W and a mean linear endovenous energy density of 72 J/cm. J Vasc Interv Radiol 2014;25:1795-800.
15. Beyazal M, Avcu S, Ozen O, Yavuz A, Bora A, Unal O. Endovenous laser ablation treatment with 980 nm diode laser for saphenous vein insufficiency: 6 months follow up results. JBR-BTR 2014;97:336-40.
16. Altin FH, Aydin S, Erkoc K, Gunes T, Eygi B, Kutas BH. Endovenous laser ablation for saphenous vein insufficiency: short- and mid-term results of 230 procedures. Vascular 2015;23:3-8.
17. Starodubtsev V, Lukyanenko M, Karpenko A, Ignatenko P. Endovenous laser ablation in patients with wide diameter of the proximal segment of the great saphenous vein: comparison of methods. Phlebology 2015;30:700-5.
18. Atasoy MM. Efficacy and Safety of Endovenous Laser ablation in very large and tortuous great saphenous veins. J Vasc Interv Radiol 2015;26:1347-52.
19. Nejm CS Jr, Timi JR, de Araujo WB Jr, Caron FC. Endovenous laser ablation of the great saphenous vein - Varying energy may not affect outcome. Phlebology 2017;32:13-8.
20. Park I. Initial outcomes of endovenous laser ablation with 1940 nm diode laser in the treatment of incompetent saphenous veins. Vascular 2019;27:27-32.
21. Srivatsa SS, Chung S, Sidhu V. The relative roles of power, linear endovenous energy density, and pullback velocity in determining short-term success after endovenous laser ablation of the truncal saphenous veins. J Vasc Surg Venous Lymphat Disord 2019;7:90-7.
22. Elias S, Raines JK. Mechanochemical tumescentless endovenous ablation: final results of the initial clinical trial. Phlebology 2012;27:67-72.
23. Bishawi M, Bernstein R, Boter M, Draughn D, Gould CF, Hamilton C, et al. Mechanochemical ablation in patients with chronic venous disease: a prospective multicenter report. Phlebology 2014;29:397-400.
24. Bootun R, Lane TR, Dharmarajah B, Lim CS, Najem M, Renton S, et al. Intra-procedural pain score in a randomised controlled trial comparing mechanochemical ablation to radiofrequency ablation: the Multicentre Venefit versus ClariVein(R) for varicose veins trial. Phlebology 2016;31:61-5.
25. Kim PS, Bishawi M, Draughn D, Boter M, Gould C, Koziarski J, et al. Mechanochemical ablation for symptomatic great saphenous vein reflux: a two-year follow-up. Phlebology 2017;32:43-8.
26. Mueller RL, Raines JK. ClariVein mechanochemical ablation: background and procedural details. Vasc Endovascular Surg 2013;47:195-206.
27. Tal MG, Dos Santos SJ, Marano JP, Whiteley MS. Histologic findings after mechanochemical ablation in a caprine model with use of ClariVein. J Vasc Surg Venous Lymphat Disord 2015;3:81-5.
28. Whiteley MS, Dos Santos SJ, Lee CT, Li JM. Mechanochemical ablation causes endothelial and medial damage to the vein wall resulting in deeper penetration of sclerosant compared with sclerotherapy alone in extrafascial great saphenous vein using an ex vivo model. J Vasc Surg Venous Lymphat Disord 2017;5:370-7.

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