

RESEARCH ARTICLE

Factors Associated with the Clinical Outcomes of Ankle Instability Surgery

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Abstract

Objectives: More than 20% of patients experience chronic lateral ligamentous instability of the ankle (CLLIOTA) following the appropriate management of an ankle sprain. The modified Broström-Gould (MBG) procedure has become the standard treatment for the anatomic repair of symptomatic CLLIOTA. The present study aimed to evaluate the clinical and functional outcomes of the MBG technique in patients with CLLIOTA and investigate factors affecting the outcome of surgery.

Methods: This retrospective, single-group study included all patients with CLLIOTA who underwent surgery using the MBG technique in Shahid Kamyab Hospital, Mashhad, Iran, between July 2015 and August 2020. The American Orthopedic Foot and Ankle Score (AOFAS), Manchester-Oxford Foot Questionnaire (MOXFQ), and Pain Visual Analog Scale (VAS) were used to evaluate the outcome. The correlation between patient-related factors and each outcome measure was also analyzed.

Results: In total, 38 patients underwent the MBG procedure. The mean follow-up was 40.1 (18-67) months. Overall, 15 patients (39.47%) had a history of sports-related ankle sprains, and 15 (39.47%) had ankle osteochondral lesions. The AOFAS score improved significantly (51.23 ± 13.49 to 91.92 ± 12.077 , $P < 0.001$), while MOXFQ and VAS scores decreased significantly in the follow-up evaluation (50.28 ± 9.33 to 27.5 ± 13.35 , $P < 0.001$, and 6.2 ± 1.47 to 2.18 ± 1.86 , $P < 0.001$, respectively). No significant correlation was found between pre-operative ankle osteoarthritis, talus osteochondral lesion, duration of the follow-up, ankle sprain etiology (sports vs. non-sports), age, body mass index, gender, and the interval between the first sprain and surgery on the one hand, and post-operative outcomes, on the other hand. The more time passed after the surgery, the less painful the ankle of the patient was ($P = 0.038$). No failure was observed among the patients.

Conclusion: This study showed that the open MBG technique for CLLIOTA can improve clinical outcomes with no major complications following surgery in the Iranian population.

Level of evidence: III

Keywords: Ankle, Clinical outcomes, Lateral ligamentous instability, Orthopedics, Reconstruction

Introduction

Chronic lateral ligamentous instability of the ankle (CLLIOTA) accounts for 13-55% of sports-related injuries.^{1,2} Around 10-30% of patients fail conservative treatment and require surgical management.³ The Broström technique has become the gold standard for the surgical treatment of CLLIOTA if the anterior talofibular ligament is appropriate for anatomic

repairmen.⁴ In the modified Broström-Gould (MBG) technique, the lateral part of the inferior extensor retinaculum is augmented, which has been shown to lead to much better results than a simple ligamentous repair.^{5,6} Lee et al. have also reported that the MBG technique can successfully repair the calcaneofibular ligament.⁷

Although previous studies have documented and

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compared outcomes after various procedures, few have evaluated the outcome of a single MBG technique in one medical center by a single surgeon. Some studies have reported that factors such as gender, body mass index (BMI), and age do not correlate with the outcome of surgery.⁸ However, there are some other patient-related factors, such as ankle osteochondral lesion, grade of ankle osteoarthritis (OA), duration of symptoms, duration of the follow-up, repairment device, and etiology of the injury (sports vs. non-sports), that might cause pain after the surgery and disturb its outcomes, which have not been thoroughly evaluated.

This study aims to evaluate the clinical and functional outcomes of the MBG technique in patients with CLLIOTA. The second goal is to assess factors affecting the outcome of surgery. For this purpose, we retrospectively reviewed all surgeries with the same MBG technique by a single surgeon in the same orthopedics department.

Materials and Methods

Study Setting and Ethics

This study included all patients with CLLIOTA who underwent surgery using the MBG technique performed by a single orthopedic surgeon between July 2015 and August 2020. Informed consent was obtained from all patients before the surgery, and ethical approval was granted by the hospital's Quality, Safety, and Ethics Committee (approval number: removed due to blinding).

Patients

The medical records of 73 CLLIOTA patients between 2015 and 2020 were evaluated. Of those, 18- to 65-year-old patients with symptomatic CLLIOTA for more than six months who did not respond to conservative treatments and underwent surgery were included in this study. On the other hand, patients with a history of unhealed ankle fracture, generalized ligamentous laxity, or insufficient ligament for repair were excluded from the analysis.

Accordingly, 67.1% (46) were eligible. A further 4.1% (3) were excluded because of a history of unhealed ankle fractures, and another 6.8% (5) were excluded due to not having enough ligaments for repair and reconstruction techniques, leaving 52.05% (38) for analysis in this retrospective study.

Study Design

As this was a retrospective study, the data were extracted from patients' document files. Afterward, the patients were called to check their response to the treatment and fill out the questionnaires. Before surgery, a complete examination was performed for each patient, including the ankle anterior drawer test, inversion and eversion stress tests, external rotation stress test, squeeze test, and cotton test. The resulting information from all trials was recorded in patients' files. Anteroposterior, lateral, mortise, inversion stress view, and anterior stress view radiographs, as well as a 1.5 Tesla Magnetic Resonance Imaging of the ankle, were taken. Based on pre-operative radiographs and the Kellgren Lawrence scale (K&L scale), the staging of ankle OA was documented. Outcome measures included the American Orthopaedic Foot and Ankle Society (AOFAS), Manchester-Oxford Foot Questionnaire (MOXFQ), and Visual Analog Scale (VAS) for

pain, with 0 representing no pain and 10 representing severe pain.

Tools

The MOXFQ, which has four parts, evaluates foot and ankle function, with 100 being the worst score and 0 being given to patients with no pain and without difficulty walking.⁹ The AOFAS scale has three parts. Two parts are subjective and about function and pain, but the third part is about limb alignment, which the orthopedic surgeon must record. The validated version of the modified Persian questionnaire was used in this study.¹⁰ All patients underwent diagnostic arthroscopy before the main surgery to rule out osteochondral lesions of the talus or other intra-articular pathologies that may cause pain and bias in post-operative findings. All patients underwent surgery with the MBG technique by a single surgeon. At the time of surgery, detailed surgical procedures and intraoperative findings were documented prospectively for all patients.

Surgical Technique

First, stress radiographs were performed preoperatively [Figure 1]. As mentioned, patients underwent an arthroscopic evaluation of the ankle joint before lateral ligament repair [Figure 2]. The articular cartilage of the ankle was evaluated, and debridement, osteophyte excision, and loose body removal were performed if necessary. If the rupture of the lateral ligaments of the ankle (anterior talofibular ligament or calcaneofibular ligament) was proven by diagnostic arthroscopy, a curved incision was made 5 cm proximal to the distal tip of the fibula and 1.5 cm anterior to its margin [Figure 3]. The lateral branch of the superficial peroneal nerve and the sural nerve were protected in each case. The lateral portion of the inferior extensor retinaculum was explored, mobilized, and tagged for the end of the surgery. Afterward, the ankle joint capsule was sectioned, the peroneal tendon sheet was incised, and the anterior talofibular and calcaneofibular ligaments were exposed. Subsequently, the tears of the ligaments were exposed and observed. If the tear was in the mid-substance of the ligament, the repair was done with an Ethibond suture using an end-to-end technique. If ligaments were avulsed, or there was not enough ligament to repair, an anchor suture was placed in the fibula or neck of the talus to perform the repair. The repair addressed the valgus of the ankle, as well as the eversion and abduction of the foot. The calcaneofibular ligaments were also observed, and if a tear was seen, the ligament was repaired.

After the repair, the stability and range of motion of the ankle were checked. The correction was done if there was a lack of range of motion or instability. After that, the lateral portion of the inferior extensor retinaculum, which was mobilized before, was repaired to the fibula in a position that limited the inversion of the ankle. The capsule was then repaired, and the wound was closed layer by layer.^{5,11-15}

After the surgery, the patient took a short leg cast for four weeks. Sutures were removed, and after six weeks, the range of motion began to increase gently for the patient, and full weight bearing was allowed. However, inversion past the

neutral position was not permitted until eight weeks after the surgery.

The complications and post-operative examination observations were documented during the follow-up visits.



Figure 1. Inversion stress radiographs and anterior drawer stress radiographs taken from all patients before the surgery

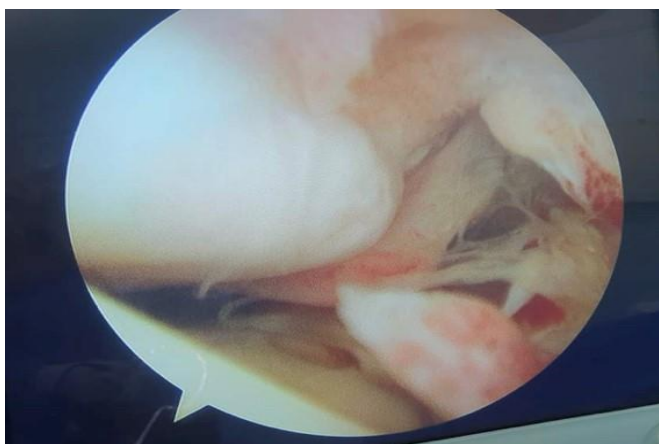


Figure 2. Arthroscopic evaluation of torn lateral ligaments of the ankle before the surgery



Figure 3. Curved incision for the MBG technique

Outcome of Interest (Primary and Secondary Outcomes)

Primary: The Persian MOXFQ is a valid patient-reported instrument for CLLIOTA.⁹ The Persian translation of the AOFAS has also been validated for use in CLLIOTA.¹⁰ The VAS, MOXFQ, and AOFAS questionnaires were completed before surgery and recorded in patients' files. Patients were requested to visit the clinic at least 18 months after surgery to complete the questionnaires again.

Secondary: The association between patient-related factors and the primary outcome results was evaluated. The patient's age, gender, and BMI were documented. The type of primary injury was recorded based on the patients' statements. The presence of ankle cartilage lesions was evaluated and recorded by the surgeon during the diagnostic arthroscopy and extracted from the patients' files. The K&L scale is validated for the radiographic grading system to assess ankle OA.¹⁶

Statistical Analysis

The normality of the distribution of variables was investigated using the Kolmogorov-Smirnov test and the Shapiro-Wilk test ($P > 0.05$ was considered normal). Afterward, the Paired Samples t-test or the Wilcoxon test (based on the normality of the data distribution) was used to compare primary outcome results before and after the surgery. The difference between pre-operative and post-operative scores was also calculated. To investigate the correlation between quantitative variables (age, BMI, the interval between the first sprain and surgery, and the interval between surgery and the second examination), as well as delta scores before and after surgery, Pearson and Spearman correlation coefficient tests were used ($P < 0.05$ was considered significant). To investigate the correlation between qualitative variables (gender, the type of trauma causing the injury, and the presence of osteochondral lesion), as well as delta scores before and after surgery, a parametric t-test or the non-parametric Mann-Whitney U-test was used. Moreover, to investigate the correlation between ankle OA grade before surgery and delta scores before and after surgery, the Kruskal-Wallis test or one-way analysis of variance was used ($P < 0.05$ was considered significant).

Results

Descriptive Data

In total, 38 patients with a mean age of 34.1 years were included in this study (range: 18-53). Most of them were male (65.78%), and the average BMI was 27.135 (range: 17.95-40.12). Overall, 39.47% of patients had a history of sports-related ankle sprains, and 60.52% had non-sports-related ankle sprains. The shortest interval between the first ankle sprain and surgery was six months, and the most extended break was 60 months. Two patients were professional athletes. The average duration of the follow-up was 40.1 months (range: 18-67) [Table 1].

Clinical Outcomes

The AOFAS, MOXFQ, and VAS scores improved significantly after surgery ($P < 0.001$) [Table 2]. In the post-operative examination, all ankles were stable. Overall, 27 patients

(71.05%) had a completely normal ankle stability examination, nine patients (23.68%) had tenderness over

the lateral malleolar area, and two patients (5.2%) had a painful ankle inversion stress test.

Table 1. Population demographic data (N=38)	
variable	Data
Sex number (%)	
Women	13 (34.2%)
Men	25 (65.8%)
Age (year) mean \pm SD	
	34.10 \pm 9.8
BMI mean \pm SD	
	27.13 \pm 4.5
Etiology number (%)	
<i>Sport</i>	15 (39.5%)
<i>Non-sport</i>	23 (60.5%)
Ankle osteochondral lesion number (%)	
<i>Yes</i>	15 (39.5%)
<i>No</i>	23 (60.5%)
Device used for ligament repair number (%)	
<i>Ethibond</i>	7 (18.4 %)
<i>Anchor suture</i>	31 (81.6%)
K&L scale for ankle OA number (%)	
<i>Normal</i>	32 (84.2 %)
<i>Grade 1</i>	4 (10.5 %)
<i>Grade 2</i>	2 (5.3 %)

K&L: Kellgrene Lawrence scale; OA: Osteoarthritis

Table 2. comparison of the results of the MBG technique before and after surgery based on the Wilcoxon test			
scores	Pre-op (mean \pm SD)	Post-op (mean \pm SD)	p-value
VAS pain	6.23 \pm 1.47	2.18 \pm 1.86	0/001<
AOFAS	51.23 \pm 13.49	91.92 \pm 12.077	0/001<
MOXFQ	50.28 \pm 9.33	27.5 \pm 13.35	0/001<

AOFAS: American Orthopaedic Foot and Ankle Society; MOXFQ: Manchester-Oxford Foot Questionnaire;

VAS: visual analog scales; pre-op: preoperative; post-op: postoperative

Factors Affecting the Outcome of Surgery

No significant correlation was found between pre-operative ankle OA, talus osteochondral lesion, ankle sprain etiology (sports vs. non-sports), age, BMI, gender, and the interval between the first sprain and surgery, on the one hand, and post-operative results, on the other hand [Tables 3 and 4]. There was a significantly negative correlation between post-operative VAS scores and the duration of the follow-up [Table 3]. There were no complications or failures after surgery.

Discussion

The current study analyzed 38 CLLIOTA patients who were treated surgically with the MBG technique by a single orthopedic surgeon. With an average follow-up of 40 months, the results demonstrated that the MBG technique, regardless of the device used for ligament repair (Ethibond or anchor suture), could reduce pain and improve the patients' function. The majority of previous studies compared the outcome of CLLIOTA repair to that of reconstruction

techniques. They mainly concluded that repair techniques, such as the MBG, are superior and the gold standard for CLLIOTA treatment, as reconstruction techniques have more complications, such as superficial infections, paresthesia, deafness, and the loss of normal gait kinematics.¹⁷⁻¹⁹ most studies support the use of MBG techniques, and their post-operative results are comparable to ours. The AOFAS score in Vuurberg et al.'s systematic review study²⁰ (119 ankles and 76 months of follow-up) was 93.8 \pm 2.7. Singh et al.²¹ found that the post-operative AOFAS scores of 15 CLLIOTA patients were 94 at a two-year follow-up. In a study conducted by Jain et al.²² on 87 patients with 24.2 \pm 5.1 months of follow-up, the post-operative VAS and MOXFQ scores were 1.9 \pm 1.5 and 19.7 \pm 22.2, respectively. The AOFAS score in the study by Beurre et al.²³ was 91.12. However, in a meta-analysis conducted by Zhu²⁴ on 426 patients with CLLIOTA, it was found that the AOFAS scores were much higher with other operation techniques (Chrisman Snock) than with the MBG technique. It was noted that the MBG technique is not appropriate for repairing patients with a

lack of torn ligaments. For this reason, we excluded these patients from our study, and there is no specific reference to these patients in other studies as well. However, it is evident that the first condition for repair techniques, such as the

MBG, is to have enough ligaments to repair. The MBG technique's lack of indication in these patients does not mean the procedure is weak.

Table 3. Evaluation of correlation between quantitative independent and Dependent variables (Questionnaire scores)

Quantitative independent variable	Quantitative dependent variable	Coefficient of correlation	P-value
Age	Postoperative VAS ¹	0.014	0.935
	Postoperative AOFAS ¹	0.051	0.760
	Postoperative MOXFQ ¹	-0.013	0.939
	DBPAP VAS ¹	-0.010	0.951
	DBPAP AOFAS ²	-0.155	0.354
	DBPAP MOXFQ ²	0.174	0.297
BMI	Postoperative VAS ¹	-0.076	0.652
	Postoperative AOFAS ¹	0.007	0.967
	Postoperative MOXFQ ¹	-0.090	0.591
	DBPAP VAS ¹	-0.089	0.596
	DBPAP AOFAS ¹	0.161	0.336
	DBPAP MOXFQ ¹	-0.003	0.987
DBFSAS	Postoperative VAS ¹	0.157	0.345
	Postoperative AOFAS ¹	-0.108	0.520
	Postoperative MOXFQ ¹	0.212	0.202
	DBPAP VAS ¹	-0.188	0.259
	DBPAP AOFAS ²	-0.044	0.791
	DBPAP MOXFQ ²	-0.174	0.297
DUF	Postoperative VAS ¹	-0.338	0.038*
	Postoperative AOFAS ¹	0.233	0.160
	Postoperative MOXFQ ¹	-0.087	0.604
	DBPAP VAS ¹	0.164	0.325
	DBPAP AOFAS ²	-0.44	0.006*
	DBPAP MOXFQ ²	0.257	0.119

AOFAS: American Orthopaedic Foot and Ankle Society; MOXFQ: Manchester-Oxford Foot Questionnaire; VASs: visual analog scales;

DBPAP: Difference between pre-operative and postoperative; DBFSAS: Duration between first sprain and surgery; DUF, Duration of follow up

¹:spearman test, ²: Pearson test

Table 4. Evaluation of correlation between Qualitative independent and Dependent variables (Questionnaires scores)

Qualitative independent variable	Quantitative dependent variable	Test statistics	p-value
Device used for ligament repair	Postoperative VAS ¹	0.149	0.700
	Postoperative AOFAS ¹	0.789	0.374
	Postoperative MOXFQ ²	0.067	0.797
	DBPAP VAS ¹	0.093	0.761
	DBPAP AOFAS ²	0.046	0.831
	DBPAP MOXFQ ²	0.076	0.784
K&L scale for ankle OA	Postoperative VAS ¹	1.308	0.520
	Postoperative AOFAS ¹	2.666	0.264
	Postoperative MOXFQ ²	1.911	0.163
	DBPAP VAS ¹	0.237	0.888
	DBPAP AOFAS ²	0.289	0.751
	DBPAP MOXFQ ²	0.722	0.493

Table 4. Continued			
Gender (male or female)	Postoperative VAS ³	114.500	0.131
	Postoperative AOFAS ³	138.500	0.449
	Postoperative MOXFQ ⁴	-1.368	0.180
	DBPAP VAS ⁴	1.818	0.077
	DBPAP AOFAS ⁴	-0.991	0.335
	DBPAP MOXFQ ⁴	0.484	0.631
Type of injury (Sport vs. non-sport)	Postoperative VAS ³	150.000	0.492
	Postoperative AOFAS ³	157.500	0.646
	Postoperative MOXFQ ⁴	0.868	0.391
	DBPAP VAS ⁴	148.000	0.460
	DBPAP AOFAS ⁴	-1.005	0.321
	DBPAP MOXFQ ⁴	-0.297	0.768
Ankle osteochondral lesion	Postoperative VAS ³	0.157	0.345
	Postoperative AOFAS ³	-0.108	0.520
	Postoperative MOXFQ ³	0.212	0.202
	DBPAP VAS ⁴	-0.188	0.259
	DBPAP AOFAS ⁴	-0.044	0.791
	DBPAP MOXFQ ⁴	-0.174	0.297

AOFAS: American Orthopaedic Foot and Ankle Society; MOXFQ: Manchester-Oxford Foot Questionnaire; VASs: visual analog scales;

DBPAP: Difference between pre-operative and postoperative; DBFSAS: Duration between first sprain and surgery

¹: Kruskal variance, ²: one-way analysis of variance, ³: Mann Whitney test, ⁴: T-tests

These days, patients prefer having less invasive surgeries with smaller scars; therefore, arthroscopic techniques are the preferred method for most surgeries, as they involve fewer complications and patients are more satisfied. However, the problem in Iran is that the cost of arthroscopic surgeries is much higher, and thus many patients cannot afford them. The results of the arthroscopic study by Sanchez et al.²⁵ were comparable to ours. In their study, the pre-operative and post-operative scores were 55.4±14.41 and 93.7±6.71, respectively, and in our study, they were 51.23±13.49 and 91.92±12.077, respectively. We thus hypothesize that an open operation in Iran is more beneficial for CLLIOTA.

Another technique used for CLLIOTA is the MBG technique, which uses suture tape augmentation. Some studies have reported more stability and better functional outcomes for this technique. In the study by Hugo et al.²⁶ in 2022, the MBG technique was used with suture tape augmentation in 55 patients with CLLIOTA. However, their results were quite similar to ours, in terms of pain and function.

Some studies have shown that augmentation with a periosteal flap (PFA) could improve the results of the MBG technique. A recent study by Tay et al.²⁷ compared two groups of 24 patients treated with the conventional MBG technique and the MBG technique with PFA. The comparison of the findings in our study to those in these two groups showed that all groups had similar results. Therefore, the open MBG technique in Iran (or other developing and underdeveloped countries) appears to be the best option for treating CLLIOTA patients with sufficient ligaments to repair.

Factors Affecting the Outcome of Surgery

We found that factors such as age, gender, BMI, the interval between the first sprain and surgery, the type of initial injury (sports vs. non-sports), osteochondral lesions of the ankle, and pre-operative lesion grade did not affect the outcome of surgery. There was a negative correlation between the duration of the follow-up and the post-operative VAS pain score, indicating that the more time passed after the surgery, the less pain the patient experienced. Although a few studies have evaluated the correlation of demographic factors, such as age, gender, and BMI, with functional outcomes of the MBG technique,²⁸⁻³⁰ no study has addressed all patient baseline factors. In the study by Lee et al.⁸ in 2019, 60 patients underwent the MBG technique with a mean age of 19.3. They reported that age, BMI, gender, and the level of pre-operative sports activity did not correlate with the average time of return to training. Another retrospective study by Sakkab et al.³¹ in 2021 evaluated factors that may affect the time patients need before returning to activity and reported that males began weight-bearing as tolerated in a walking boot 1.08 weeks earlier than females (P=0.053). Workers looking to get money from the insurance had a much later return to work (+0.431, P<0.001). On the other hand, physical therapy sessions did not significantly correlate with the time needed to return to activity (+0.063, P=0.622). Park et al.³² studied 199 patients with CLLIOTA who underwent surgery with the MBG technique with a mean follow-up of 60 months and reported that the presence of generalized ligamentous laxity was significantly associated with poor clinical and radiological outcomes (P<0.001). This factor was one of the exclusion criteria in our study design since generalized joint

hypermobility needs to be recognized and discussed with patients preoperatively, and they need lateral ligament transection and imbrication, not the simple MBG technique.³³ Contrary to our results, Hua et al. reported that ankle chondral lesions at prior arthroscopy had a significantly negative correlation with post-operative AOFAS scores.³⁴ This could be due to the fact that none of the studies graded the chondral lesion.

This is the first study evaluating the correlation between patient-related factors (age, BMI, the interval between the first sprain and surgery, the interval between surgery and the second examination, gender, the type of trauma causing the injury, the presence of osteochondral lesion, the grade of ankle OA before surgery, as well as the device that is used for repair) and clinical scores after the use of the MBG technique by a single orthopedic surgeon. The resultant scores were close to those from previous investigations: reduced pain and increased function after the surgery. We suggest further longitudinal studies for a more robust conclusion on this topic.

Limitations

This study has several limitations. First, it was conducted on only 38 patients (but with adequate power). Second, the exclusion of patients with extensive ligamentous laxity and insufficient ligament to repair lowers the generalizability of the findings. However, including patients with generalized ligamentous laxity and insufficient ligament to repair in the study may have biased the results against the MBG operation because the MBG is often contra-indicated in these situations. Given these restrictions, the current study has shown that, in terms of cost and clinical outcomes, the open MBG approach in Iran (or other developing and undeveloped countries) appears to be the best option for treating CLLIOTA patients with enough ligaments for repair. More research is needed to establish the success of the reconstruction procedure in patients with a ligament that cannot be repaired.

Conclusion

We found that the MBG technique for CLLIOTA improves functional and clinical outcomes with no significant complications following surgery. Furthermore, there is no correlation between patient-related factors and post-operative pain and function scores.

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Authors Contribution:

Performing the operations and follow up: Yashar Shahbaz, Mahla Daliri.

Study concept and design: Sayyed Hadi Sayyed Hoseinian. Draft and revised the paper: Yashar Shahbaz, Mahla Daliri, and Mohammad H. Ebrahimzadeh.

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Critical revision of the manuscript for important intellectual content: Sayyed Hadi Sayyed Hoseinian, Yashar Shahbaz, Mahla Daliri, and Mohammad H. Ebrahimzadeh.

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(<https://ethics.research.ac.ir/>) (Attachment 1) and was conducted in accordance with the ethical standards in the 1964 Declaration of Helsinki.

Declaration of Informed Consent: Patients were provided with written informed consent forms before enrolment. There is no information (names, initials, hospital identification numbers, or photographs) in the submitted manuscript that can be used to identify patients.

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