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Original Article

Deltoid Ligament Reconstruction in Lateral Malleolus Fractures with Deltoid Rupture

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Abstract

Background: Treatment of lateral malleolus fractures is a controversial issue, especially when is associated with deltoid ligament (DL) rupture

Objectives: In the present study, the effect of DL repair in patients with lateral malleolar fractures with deltoid rupture was investigated on medial clear space (MCS), ankle-hindfoot score (AHS), and malreduction rates.

Methods: 65 patients who referred with lateral malleolus fracture plus DL rupture during 2017-2018 and underwent surgery were studied. The diagnosis was conducted by a single renowned orthopedic surgeon according to physical examination, clinical, and paraclinical findings such as radiography. A questionnaire was used to record demographic information, pain severity, duration of follow-up, AO classification, pre- and postoperative MCS, AHS, and malreduction and data of the patients with and without DL reconstruction were compared using SPSS software (version 21).

Results: About half of the patients (51%) were men. DL was reconstructed in 50.8% of the patients. AO category of the most (53.8%) of the patients was class-B. There was no difference between the patients with and without DL reconstruction in the frequency of fibular malreduction, mean pain severity, and AHS (P>0.05). Mean MCS was neither different between the groups before (P=0.946), nor after surgery (P=0.794). Mean change in MCS score was -2.03±0.95 and -1.94±0.95 in the groups with and without DL reconstruction, respectively (P=0.606).

Conclusion: This study showed that DL reconstruction did not affect the medial clearance space. Further studies are required on stability and biomechanics to determine which injuries need surgery and which ones need conservative treatment.

Keywords: Ankle Fractures; Closed Fracture Reduction; Ligaments.

Introduction

Ankle fractures as common fractures with an incidence of approximately 170-180 fractures per 100,000 person-year predominantly consist of malleolar fractures.[1,2] The alignment of the ankle joint, which causes gaits if impaired, is maintained by the ring of bones and ligaments in two lateral and medial columns of the ankle.[3,4] The stability of lateral malleolus fractures, which may occur alone or with medial malleolus fractures, is a fundamental issue and the integrity of deep fibers of deltoid ligament is suggested to play a major role in the stability of lateral malleolus fractures.[5,6]

Deltoid ligament (DL), the medial ligament of talocrural joint, comprises tibiospring, tibionavicular, superficial posterior tibiotalar, and tibiocalcaneal ligaments (components of the superficial portion), and deep posterior and anterior tibiotalar ligaments (components of the deep portion) that spans out from the medial malleolus toward the talus, calcaneus, and navicular bones and maybe ruptured by supination and external rotation mechanism.[7,8] Clinical signs of deformity, malalignment, tenderness, ecchymosis or hematoma at the medial side of the ankle may not always be present in DL lesions, and radiography is recommended for guiding the clinical diagnosis using the widening of medial clear space (MCS) in stress view as well as the use of Lauge-Hansen classification system.[9,10] More accurate imaging techniques, such as magnetic resonance imaging (MRI), are recommended for assessing the mechanism of injury and the presence of soft-tissue damage associated with ankle fractures.[11,12]

Despite the significant role of DL in ankles' stability, the benefit of MCS correction and DL reconstruction still remains a challenge.[13] Some studies reported that DL repair during lateral malleolus fixation has similar subjective, functional, and radiological outcomes compared with syndesmotic fixation, with lower costs and fewer surgical

risks and is thus a superior technique,[14] while review of the literature specifies that exploration of MCS is only required in cases with interposition on the medial side and adequate reduction in the fibular fracture and normalization of MCS is adequate.[9] Some other studies emphasize on the necessity of repairing the anterior DL for restoring medial stability in high-grade unstable lateral malleolus fractures.[11] Some others have recommended that DL repair can reduce malreduction rate only in AO type-C ankle fractures, but not in AO type-B ankle fractures.[15] However, these studies have not compared their results with a control group, which can be considered as a main limitation.

Objectives

According to the knowledge gap in this regard and the limitations of the previous studies, the present study aimed to study the effect of DL repair in patients with lateral malleolar fractures with deltoid rupture.

Materials and Methods

Study design

This prospective cross-sectional study included all adult patients (age >18 years) who referred to our clinic with closed lateral malleolar fracture plus DL rupture during 2017-2018 and underwent surgical treatment. The patients' MCS was evaluated in malleolar view of radiography by foot supination and external rotation and measured in accordance with the American Orthopedic Foot and Ankle Society (AOFAS) criteria and those with a MCS >3 mm who were followed up for 4 months, did not undergo surgery later than 14 days after injury, had neither pathological fractures, lower limb dysfunction, nor DL rupture with medial malleolar fracture were included in the study. All the patients who met the inclusion criteria were enrolled in the study by non-randomized method (census method). Before patient recruitment, the researcher explained the study's design and objectives to the participants and asked them to read and sign the written informed consent form, if they were willing to participate in the study. The protocol of the study was approved by the Ethics Committee of Guilan University of Medical Sciences (code: IR.GUMS.REC.1397.505).

Diagnosis of fracture and indication of surgery was confirmed by a single renowned orthopedic surgeon according to physical examination, clinical, and paraclinical findings such as radiography. The researcher recorded the demographic information (sex and age) and trauma mechanism (cause of injury) in the study checklist. All the patients underwent closed reduction of the lateral malleolar fracture. All procedures were performed by one surgical team with a similar technique. Sex months after the surgery, the researcher asked the patients to rate the severity of their postoperative pain on a 10-point visual analog scale (VAS), in which 0 indicates no pain and 10 indicates the worst pain ever.

Ankle-hind foot index (AHS) was measured 6 months after the surgery, as defined by AOFAS, and then recorded in the study checklist and the AO Foundation classification (Association for the Study of Internal Fixation) of the patients was also recorded. MCS scores before and after surgery and malreduction, as well as the duration of follow-up, were also recorded in the study checklist.

Statistical analysis

The qualitative variables were first described by frequency (percentage) and compared between the groups using Chi-square and Fisher's exact tests, according to the number of the participants in each group. For the statistical analysis of the quantitative variables, first Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess the normal distribution of the data, which showed that the quantitative variables did not have a normal distribution. Accordingly, mean ± standard deviation (SD) and median was used for description of these variables, and Mann-Whitney U test was used for comparing the groups. For the statistical analysis, the IBM SPSS software (Version Windows version 21.0, BM Corp. 2012. Armonk, NY: IBM Corp) was applied. P values of 0.05 or less were considered statistically significant.

Results

A total of 65 patients were included in the statistical analysis; 51% were men, and 49% were women, and 40% of the patients were in the age range 21-40 years. The mean±SD of patients' age was 34±2.12 years. DL was reconstructed in 50.8% (N=33) of the patients. Distribution of age categories, sex, mechanism of trauma, and fibular malreduction were not different between the patients with and without DL reconstruction (P>0.05), but the distribution of AO classification was different (P=0.035, Table-1). There was no difference between the patients with and without DL reconstruction in the mean duration of follow-up, pain severity, and AHS (P>0.05, Table-1).

Table-1. Comparing the demographic and clinical characteristics of the study population according to deltoid ligament reconstruction

		Total	Patients with reconstructed ligament (N=33)	Patients without reconstructed ligament (N=32)	P value
Age category, No (%)	<20 years	7 (11)	4 (12.1)	3 (9.4)	0.999†
	21–40years	26 (40)	13 (39.4)	13 (40.6)	
	41–60years	19 (29)	9 (27.3)	10 (31.3)	
	>61years	13 (20)	7 (21.2)	6 (18.8)	
Sex, No (%)	Male	33 (51%)	15 (45.5)	18 (56.3)	0.384*
	Female	32 (49%)	18 (54.5)	14 (43.8)	
Duration of follow-up, mean±SD		5.85±2.01	5.73±2.04, median=6	5.79±2.01, median=6	0.806‡
Trauma mechanism, No (%)	Fall from height	15 (23.1)	8 (24.2)	7 (21.9)	0.999†
	Sport injuries	13 (20)	7 (21.2)	6 (18.8)	
	Road accidents	8 (12.3)	4 (12.1)	4 (12.5)	
	Ankle twist	29 (44.6)	14 (42.4)	15 (46.9)	
Pain severity, mean±SD		2.54±1	2.55±1, median=2	2.53±1.02, median=2	0.939‡
AO classification, No (%)	A	12 (18.5)	10 (30.3)	2 (6.3)	0.035*
	B	35 (53.8)	14 (42.4)	21 (65.6)	
	C	18 (27.7)	9 (27.3)	9 (28.1)	
Fibular malrotation, No (%)	Yes	1 (1.5)	0	1 (3.1)	0.492†
	No	64 (98.5)	33 (100)	31 (96.9)	
Ankle–hindfoot score, mean±SD		78.34±7.57	79.18±7, median=80	77.47±8.05, median=78	0.388‡

* The results of Chi-square test, † The results of Fisher's exact test, ‡ The results of Mann Whitney U test.

Mean ± SD of MCS before the surgery was 4.91±1.26 in the group of patients with DL reconstruction and 4.88±1.04 in the group without DL reconstruction (with an average of 5 in both groups, P=0.946). After the surgery, mean ± SD of MCS in the group of patients with and without DL reconstruction was 2.88±0.78 and 2.94±0.85, respectively (median of 3 in both groups, P=0.794). The mean change in MCS score was -2.03±0.95 and -1.94±0.95 in the groups with and without DL reconstruction, respectively (both median of -2, P=0.606).

Studying the differences in the patients' VAS score based on the frequency or mean values of the studied variables in the study groups showed a significant difference in VAS score based on age in all the participants (P=0.012) and in patients without DL reconstruction (P=0.023). The VAS score increased with age in the two groups of patients, while it was not different in patients with DL reconstruction (P=0.133). Mean VAS was higher in women patients with DL reconstruction (P<0.001), patients without DL reconstruction (P=0.045), and all the patients (P<0.001; data not shown). However, the mean VAS score was neither different based on the mechanism of trauma, nor based on AO classification (P>0.05; data not shown).

Presurgical MCS was not different between the groups with and without DL reconstruction based on the patients' age, sex, or mechanism of trauma. A significant difference was observed between the two groups using of the Mann-Whitney U test (P>0.05; data not shown). The mean presurgical MCS was different based on AO classification and it was higher in B classin the group of patients with DL reconstruction (P=0.045) and in all the patients (P=0.020), the results of Kruskal Wallis test showed no significant difference in presurgical MCS in the patients without DL reconstruction (P=0.158; data not shown).

The results of Mann-Whitney U test showed no difference in postsurgical MCS between the patients with and without DL reconstruction based on the patients' age, sex, mechanism of trauma, and AO classification (P>0.05; data not shown), but based on the results of Kruskal Wallis test men patients (P=0.041) and the group without DL reconstruction had a higher mean postsurgical MCS (P=0.045; data not shown).

The results of Mann-Whitney U test showed that the mean AHS was not different between the groups of patients with and without DL reconstruction based on the patients' age, sex, or mechanism of trauma (P>0.05; data not shown), but the mean AHS increased by age in the group of patients with DL reconstruction (P=0.024) and according to the results of Kruskal Wallis test, the mean AHS in men was higher compared with women patients with DL reconstruction (P<0.001) as well as in all the patients (P=0.001; data not

shown). Also, the results of the Kruskal Wallis test showed the mean AHS in patients with sports injury was higher (P=0.045; data not shown).

There was no difference between the patients with or without DL reconstruction in mean difference of MCS before and after surgery based on the patients' age, sex, mechanism of trauma, or AO classification (P>0.05; data not shown). Based on the results of Kruskal Wallis test, there was a small change in men without DL reconstruction (P=0.018) in all the participants, (P=0.016; data not shown). The patients with DL reconstruction and AO class B had a larger change in MCS (P=0.022).

Discussion

In this research, the study population included patients with closed lateral malleolus fracture plus DL rupture (MCS >3 mm) who underwent open reduction internal fixation (ORIF), half with DL reconstruction (51%) and the other half without DL reconstruction (49%). Half of the patients were men, and most of them had an age range of 21-40 years. In this study, the patients' characteristics showed that closed lateral malleolus fracture could occur at any age and both sexes, with different mechanisms, as have been confirmed by previous epidemiological studies.[16,17] Furthermore, the major study population comprising the young population emphasizes on the significance of paying attention to the treatment of ankle fracture and a deeper look to the treatment options,[18] as maltreatment can result in malalignment and impaired walking gait for the patients and significantly affect the patients' quality of life (QOL) and social efficacy.[19] In the present study, the main cause of injury included ankle twist, fall from height, and sport injuries and most patients had AO class B. Juto et al, reported that the majority of ankle fractures were caused by low-energy trauma,[2] which confirms the results of the present study, reporting ankle twist as the most common mechanism of trauma. Additionally, sports injuries are reported as an important cause of ankle fractures with DL injury.[20] In fact, the mechanism of injury in patients with lateral malleolus fractures plus DL injury is similar to those with bilateral malleolus fracture and occurs when the trauma energy is not as high as fracturing the medial malleoli that causes injury in the medial side of the ankle.[21]

In the present study, the comparison of the postsurgical variables between the groups with and without DL reconstruction showed that DL reconstruction did not have any effect on the important clinical and radiological variables of ankle joints' instability, and the frequency of fibular malreduction, mean pain severity, MCS, and AHS were not different between the groups. Few studies have focused on the necessity of exploration of medial part for accurate diagnosis of DL injury and the benefits of DL reconstruction. In Lee et al., study, 35 patients with isolated lateral malleolar fractures underwent internal fixation with anterior DL repair and were evaluated by MRI for determining the degree of reduction, ligament damage, and stability. The results demonstrated that mean anterior DL grade was significantly different between the high-grade and low-grade unstable groups, but postoperative MCS was not different between the groups.[11] However, in the mentioned study, the results were not compared with a control group, without DL repair, in order to evaluate its advantages. In another study conducted by Zhao et al., the clinical and radiological outcomes of 20 patients who underwent surgical repair of DL were compared with 54 patients who did not, and the results indicated that patients in the non-repair group had a larger MCS and a significantly higher malreduction rate, but this difference between the groups disappeared after adjusting for malreduction, and there was no correlation between malreduction and treatment type. There was also no difference in mean pain severity and AHS score between the groups.[15] These results are consistent with the findings of the present study and confirm that surgical repair of DL could not reduce patients' pain or improve the ankle's stability. In the regard, further analysis in Zhao et al., study indicated a positive correlation between AO type-C ankle fractures and malreduction and reported that surgical repair of DL reduced malreduction rate in this subgroup of patients, while these results were not observed in AO type-B fracture with or without DL repair.[15] This finding is not consistent with the findings of the present study, as in our study, the patients with AO class B had a larger change in MCS in patients with DL reconstruction compared with the subtypes A and C.

The results of Koval et al., demonstrated that AOFAS score and health-related QOL were not different between 19 patients with MRI evidence of partial deep DL rupture, who underwent conservative treatment, and two patients with MRI evidence of complete deep DL rupture and all the patients were satisfied with their treatment.[22] These results suggested that the clinical outcome of surgical treatment of

DL rupture was not different from non-surgical treatment, which confirms the results of the present study, although the studied outcomes were different. In meta-analysis of 192 patients with ankle injuries, 81 in the DL repair group and 111 in the non-repair group with mean follow-up of 12 months, it was concluded that the patients with DL repair had better pain scores and MCS in follow-up, but did not differ in terms of functional outcome and postoperative complications rate compared with the non-repair group.[13] These results are in line with the findings of the present study. Nevertheless, some previous studies reported a significant difference in pain severity and MCS between the patients with and without DL reconstruction. Woo et al., reported a significant difference in mean MCS between the two groups at follow-up, but not after the surgery.[23] Gu et al., reported a greater MCS improvement, better AOFAS score, and lower pain score in the patients with DL repair,[24] which are contrary to the results of the present study. This discrepancy among the results of studies could be resulted from the differences in the study methods, such as the surgical details and the inclusion criteria. Gu et al., considered MCS ≥5 mm,[24] Woo et al., considered MCS >4 mm,[23] and Zhao considered MCS ≥6 mm on preoperative stress radiographs. Therefore, it necessary to conduct further studies in this regard. All in all, as DL repair during surgery increases the surgical duration and costs,[23,24] it is important to prevent this procedure if it has no effect on improvement of the surgical outcome.

The limitations of the present study included non-randomized patients' recruitment into the study and selecting the patients from one center, which reduces the generalizability of the study results. Another limitation of this study was the non-randomized categorization of the patients into the two groups, which increases the chance of the influence of confounders on the study results, although the main study outcome (mean preoperative MCS) was similar between the groups. Furthermore, we did not report the study outcomes at follow-up and only reported the patients' status after the surgery, while these results may be changed at different follow-up periods.

Conclusions

According to the results of this study, the surgical reconstruction of DL during ORIF had no effect on pain, mal-reduction rate and joint stability in patients with closed lateral malleolus fracture together with more than 3 mm MCS on radiography.

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Authors' Contribution

KA and MM: Conception, design, critically appraising and revising the manuscript for intellectual content. OG: Conducting the survey, extracting and gathering data, and drafting the manuscript. All the authors read and approved the final version of the article.

Conflict of Interests

The authors declare that they have no competing interests.

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Ethics approval and consent to participate

The protocol of the study was approved by the Ethics Committee of Guilan University of Medical Sciences (code: IR.GUMS.REC.1397.505). This study was performed in line with the principles of the Declaration of Helsinki. Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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