



ORIGINAL ARTICLE

Discussion Concerning Deltoid Ligament and Antero-Medial Capsule Repair in the Surgical Management of Supination External Rotation Ankle Fractures

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Abstract

Objective: To evaluate the importance of ankle deltoid ligament and anteromedial capsule repair in Lauge-Hansen Supination-External Rotation Stage IV (SER IV) ankle fractures.

Methods: A total of 15 patients with SER IV ankle fractures without medial malleolus fractures, were studied. All patients were treated with lateral malleolus Open Reduction Internal Fixation (ORIF) and transsyndesmotic screws with the deltoid ligament, as well as anteromedial capsule repair. The Lower Extremity Function Scale (LEFS), Foot and Ankle Disability Index (FADI), and Visual Analog Pain Scale (VAS) were used to assess postoperative ankle function.

Results: All 15 patients had good results; The average LEFS score was 74.3 ± 3.5 points, FADI score was 125.5 ± 5.9 points, VAS score was 1.0 ± 1.0 points.

Conclusions: Repairing the deltoid ligament and the anteromedial capsule of the ankle at the time of lateral malleolus fixation, with transsyndesmotic fixation for SER IV ankle fractures, demonstrated functional and radiologically stable outcomes. The deltoid ligament and the anteromedial capsule seemed to be important for restoration of the talus in ankle mortise, from anterior and lateral translation instability.

Keywords

SER stage IV, Ankle fracture, Surgical management, Deltoid ligament

the Lauge-Hansen classification is frequently utilized. In the classification, Supination-External Rotation (SER) injuries are the most common occurrences. In a clinical setting, SER stage IV (SER IV) can be seen as a fracture of the lateral malleolus (Weber B fibular fractures) on radiographs, when there is no medial malleolus fracture. However, the classification indicates that SER IV injuries include the syndesmotic ligament rupture and the deltoid ligament injuries (bimalleolar equivalent). Obviously, SER IV injuries are unstable ankle fractures. Both these syndesmotic and deltoid ligament injuries can allow the talus to migrate or tilt laterally within the mortise. This unstable condition can progress the widening of the medial joint space and lead to a decrease of the tibiotalar contact area. When it comes to surgical management of SER IV, surgeons may need to consider repairing both syndesmotic and the deltoid ligaments.

For surgical management for SER IV, Open Reduction and Internal Fixation (ORIF) for fractured lateral malleolus with transsyndesmotic screws are required. This is not controversial. However, surgical repair of the deltoid ligament is not considered a standard procedure. Some surgeons believe ORIF of the lateral malleolus followed by syndesmotic fixation can be enough to provide the stability of the talus, whereas others prefer to repair the deltoid ligament. There is no clear consensus in the literature as to the optimal way to stabilize the talus within the ankle mortise, and to restore the nor-

Introduction

Ankle fracture is one of the most common injuries. In order to determine the severity of ankle fractures,



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mal contact area about the ankle joint. This is because the outcome of SER IV injuries is difficult to verify, and varies in different studies [1].

Our hypothesis is that in most cases, screw stabilization of the syndesmosis has a limited effect in maintaining reduction of the talus anterior translation in SER IV injuries. Therefore, we think that repairing the deltoid ligament is necessary. In addition, when we repair the deltoid ligament, we notice that there is a substantial amount of anteromedial capsule rupture in SER IV ankle joint injuries. This thick anteromedial capsule may be a key for restraining talus anterior subluxation or dislocation, and repairing the capsule will lead to a good outcome. This study was undertaken to investigate the outcomes of SER IV, bimalleolar equivalent ankle fractures, treated with lateral malleolus ORIF with syndesmotomic fixation in addition to the deltoid ligament and the anteromedial capsule repair for correction of talus valgus and anterior translation.

Materials and Methods

Ethical approval for the study was obtained from the institution review boards. All images and operative notes for all patients, who underwent ankle operative fixation between 2014 and 2016 were reviewed. We retrospectively analyzed plain preoperative radiographs, CT scans, preoperative planning, and intraoperative radiographs. Patients with a radiographic Weber B ankle fractures (without medial malleolar fractures) but medial space widening (more than 5 mm) with external rotation stress test or gravity stress radiographs indicating deltoid ligament rupture were included in the study (diagnosed as PER IV ankle injuries) [2]. To be eligible for the study, patients had to undergo lateral malleolus ORIF with syndesmotomic fixation and deltoid ligament and anteromedial capsule repair. Multiple fractures, medial malleolar fractures, open fractures, previous an-

kle injuries and deformities, and pediatric patients (less than 16-years-old) were excluded from the study.

First, a lateral malleolar fracture ORIF was performed. With an external rotation stress test showing more than 5 mm of medial space widening, two cannulated transsyndesmotomic screws were used in order to reduce and fix the fractures and syndesmosis diastasis.

After lateral malleolar fracture ORIF with cannulated transsyndesmotomic screws, we used varus external-rotation stress and anterior-posterior stress to diagnose medial ankle laxity and anterior translation of talus. Varus external-rotation stress was more effective than valgus external-rotation stress in demonstrating talus lateral displacement in AP radiographs [3]. Talus anterior translation was observed by anterior-posterior stress test by pushing the distal tibia posteriorly. When a lateral and anterior translation of the talus was observed, the deltoid ligament and anteromedial capsule corner of the ankle joint capsule were repaired. Each step was recorded under fluoroscopy.

The suture anchor technique was used to repair the deltoid ligament and the anteromedial ankle joint capsule. The procedure involved an anteromedial skin incision along the anteromedial border of the medial malleolus. The ruptured deltoid ligament and the anteromedial capsule were exposed, and the ankle joint was irrigated. Here we evaluated, with direct vision, the talus joint cartilage surface when osteochondral lesions existed. Two suture anchors were placed over the anteromedial corner of the tibia and the tip of the medial malleolus (Figure 1). Then, the sutures were tightened with the assistant holding the ankle at 90 degrees, with a mild ankle inversion. Afterwards, the AP, lateral and mortise stress view images were taken by fluoroscopy, in order to make sure the ankle joint was evenly spaced (Figure 2).

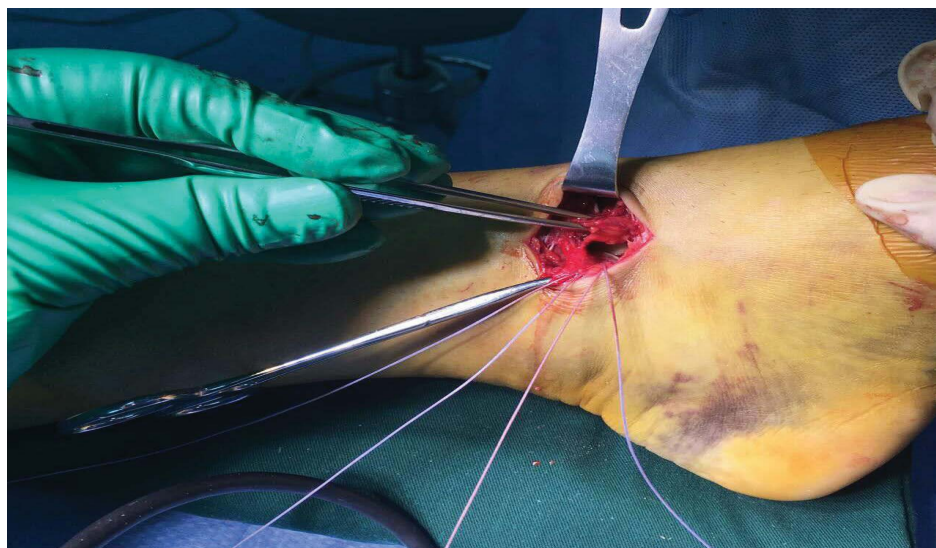


Figure 1: Suture anchor technique was used to repair the deltoid ligament and the anterior ankle joint capsule. The intraoperative photograph shows that the deltoid ligament and the anteromedial capsule of the ankle were completely ruptured.

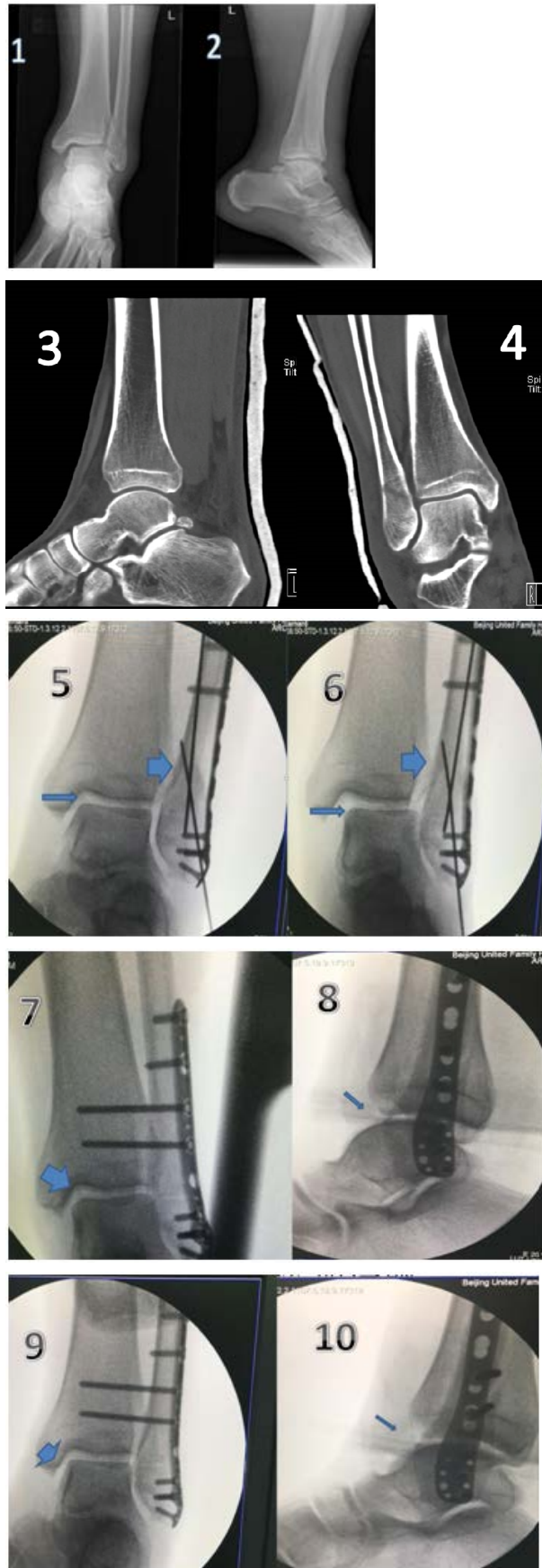


Figure 2: The radiographs show a Weber B lateral malleolar fracture without a medial malleolar fracture (1,2). CT shows no obvious anterior or lateral dislocation (3,4). Intraoperative radiographies show the medial joint space was clearly widened under the external rotation stress test (5,6). Intraoperative radiographs show, even after trans-syndesmosis screws were inserted, that medial joint space was slightly widened with varus external-rotation stress (7) and that the talus was obviously shifted in an anterior direction with anterior-posterior stress (8). Finally, after the repair of the deltoid ligament and the anteromedial ankle joint capsule, intraoperative radiographs, with another sets of stress tests, showed medial joint space was not widened and there was no talar anterior translation (9,10).

Table 1: Questionnaire results.

	Gender	Age	LEFS	FADI	VAS
1	M	25	78	131	0
2	M	34	79	129	0
3	F	64	80	134	0
4	M	43	77	128	1
5	F	37	77	125	1
6	M	34	74	118	2
7	M	43	71	123	0
8	M	45	74	130	0
9	F	69	72	127	1
10	M	51	76	129	0
11	M	26	68	112	3
12	F	61	71	125	2
13	M	41	76	130	1
14	M	35	72	124	1
15	M	39	70	117	3
		44.1 ± 13.1	74.3 ± 3.5	125.5 ± 5.9	1.0 ± 1.0

All patients were kept non-weight-bearing for six weeks. At six weeks, when there was sufficient radiographic evidence of fracture healing, weight bearing was increased as tolerated. The syndesmotic screws were removed at 12 weeks postoperatively. All patients were contacted via phone, and the study was explained in detail. Also, a packet of questionnaires and a consent form for participation in the study was given to all the patients. Questionnaires were prepared in order to evaluate the recovery in terms of pain, stability, and function which included the Visual Analog Pain Scale (VAS), Foot and Ankle Disability Index (FADI), and the Lower Extremity Function Scale (LEFS). Radiographs, at the time of final clinical follow-up, were reviewed for maintenance of reduction, especially position of the talus at the mortise in coronal and sagittal planes, and for signs of arthritic changes.

Results

There were a total of 15 enrolled patients; 12 male and 4 female. The average age was 44.1 ± 13.1 (range, 25 to 69). The average follow-up period was 11.7 ± 5.8 months (range, 3 to 25 months). The average LEFS score was 74.3 ± 3.5 points (range, 68 to 80); the average FADI score was 125.5 ± 5.9 points (range, 112 to 134). The average VAS score was 1.0 ± 1.0 points (range, 0 to 3), which showed in (Table 1).

All patients underwent an additional operation for removal of the syndesmotic implant at 12 weeks postoperatively. There were no postoperative complications that required repeat operative intervention.

Discussion

The deltoid ligament and the anteromedial capsule repair in the setting of SER IV injury (bimalleolar equivalent ankle fracture) showed a restoration of congruity to the ankle joint, and resulted in good functionality for all 15 patients. Also, we found the key for the deltoid ligament repair was to include an anteromedial joint cap-

sule to prevent talus valgus tilt and anterior translation. In the cadaver study, we found that the anteromedial joint capsule has a thick, ligament-like structure.

In the medical literature, complete deltoid ligament tears in association with lateral malleolar fractures or bimalleolar fractures are described as occasionally seen [4,5]. However we believe the medial ligaments of the ankle are injured more often than documented. Our 15 cases of SER IV injuries, without medial malleolar fractures, showed complete deltoid ligament tears with complete anteromedial capsule tears.

The deltoid ligament has a complex structure that spans from the medial malleolus to the navicular, talus, and calcaneus. It has superficial and deep layers, and consists of up to six individual ligamentous bands. The superficial components include the tibio-calcaneal ligament, tibio-navicular ligament, posterior superficial tibio-talar ligament, and tibio-spring ligament; The deep layer components include the anterior tibio-talar ligament and the posterior deep tibio-talar ligament [6,7]. Anatomical studies have shown that the posterior tibio-talar ligament is the intra-articular component of the deep deltoid [8]. The posterior tibio-talar ligament is an important stabilizer of the medial plantar arch, and its dysfunction is often associated with a tibio-spring ligament disorder, which contributes to medial ankle instability [9]. The posterior tibio-talar ligament is responsible for stabilizing the medial side of the ankle. This ligament limits external rotation of the talus. In particular, when the ankle is in plantar flexion, the posterior tibio-talar ligament restricts lateral and anterior displacement of the talus [10].

In addition to ligament stability, we think the ankle joint capsule is one of the stabilizers of ankle structure. We observed that anterior translation of the talus is an indication of anteromedial joint capsule rupture. By repairing the integrity of anterior capsule between tibia and talus, this can prevent the talus anterior translation. Therefore, repair of the anteromedial corner of joint capsule is the key to regaining the stability of the ankle.

When treating SER IV fracture without medial malleolar fracture, the decision to repair the deltoid ligament is a difficult one to make. Some studies have reported that the anterior deltoid ligament, originating from the anterior colliculus, contributes moderately to the stability of the ankle [11]. On the other hand, as early as 1976, Ramsey and Hamilton reported the disruption of the medial deltoid ligament complex allows the talus to migrate or tilt towards the lateral direction within the ankle mortise. Even subtle alteration of the misalignment will result in different movement mechanisms of the ankle and reduce joint contact areas [12]. This alteration of movement mechanisms, with fewer joint contact areas, will lead to malalignment. Total stress per surface will increase which will damage the surface cartilage areas of the ankle joint during loading, and result



Figure 3: An example case of superior-lateral dome of talus osteoarthritis with a patient who had surgery for a lateral malleolar fracture.

in earlier onset of osteoarthritis. Marx and Mizel emphasized the importance of the integrity of the deltoid ligament, with relation to the ankle stability, when they were treating SER IV fractures [13].

Lee, et al. described valgus instability of ankle joint in some patients who underwent fixation of isolated lateral malleolar fractures. In these patients, a preoperative MRI revealed deltoid ligament complex damage to various degrees [10]. This makes us aware that deltoid ligament damage can exist in patients with isolated lateral malleolus fractures, and shows some instability even after operative management. This could raise questions about some patients who suffered from SER IV ankle injury but were under-diagnosed for ligamentous injury. Some patients with SER IV injury who underwent fixation of isolated lateral malleolar fracture and syndesmotic screw fixation may still have valgus instability. It is well known that varus instability can increase the lateral distal tibial angle which will lead to higher compressive pressure on the medial side of the joint [14]. Similarly, the medial instability can lead to lateral side of the joint compressive pressure high. In these cases, the superior-lateral dome of talus has impinged on the distal lateral mortise which can result in early osteoarthritis of the superior-lateral dome (Figure 3).

Measuring the medial clear space, with or without stress, is one of the commonly used methods for indirectly evaluating the condition of the deltoid ligament. Based on Park, et al. research, the mean medial clear space ranged from 2 mm to 2.4 mm in intact ankles, under external rotation loading stress. After removing

the superficial deltoid ligament, the mean medial clear space increased to 4.3 mm. Then after cutting both of the superficial and deep deltoid ligament, the medial clear space was increased up to 6.7 mm [15]. Clinically, Harris and Fallet reported that ankle joints with lateral talar shifting, with more than 2 mm of wound, resulted in osteoarthritis [16]. Clements, et al. found that the medial clear space of more than 5 mm on stress radiographs, correlates with a low score on the American Orthopedics Foot and Ankle Society scoring system. Therefore they recommended that a medial clear space of more than 5 mm should need operative treatment [2].

Superficial deltoid ligament rupture cases can be fixed with direct end-to-end repair, fixation through bone tunnels, or suture anchor repair of avulsion injuries. Deep deltoid ligament repair has been described using direct end-to-end repair with sutures, as well as by auto graft and allograft tendon reconstruction utilizing various techniques [17]. The acute stage repair of deltoid ligament and capsule is commonly performed using a suture anchor, which is stronger than an end-to-end repair, allowing the patient earlier mobilization.

In conclusion, by primarily repairing the ruptured ligament at the same time as fracture ORIF, we think surgeons should be able to restore better anatomic congruity to the ankle joint. This retrospective study demonstrates that the repair of the deltoid ligament and the anteromedial capsule is critical for correction of the talus valgus tilt and anterior translation. This extra attention leads to a good outcome. Our study is limited by a small sample size and has no control group. However, pilot studies are frequently needed to stimulate the orthopaedic community to design a larger randomized study to further evaluate and define the importance of the repair of the deltoid ligament and the anteromedial capsule.

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