



Repair of the Acute Deltoid Ligament Complex Rupture Associated With Ankle Fractures: A Multicenter Clinical Study

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ABSTRACT

Controversy exists concerning the need for operative repair of the deltoid ligament during management of acute ankle fractures. The purpose of our report was to identify the indications for surgical intervention for deltoid ligament injury in the setting of ankle fractures. Furthermore, we aimed to elucidate the clinical outcomes after deltoid ligament repair in this setting. This was a multicenter study, involving 4 clinical institutions. From January 2006 to December 2011, 1533 ankle fractures underwent surgical intervention. Of this group, 131 deltoid ligament ruptures (8.55%) were identified and repaired operatively. Of the 131 patients, 74 were male (56.5%) and 57 were female (43.5%), with a mean age of 33.2 (range 16 to 63) years. The outcome measures included the clinical examination findings, radiographic findings, American Orthopaedic Foot and Ankle Society ankle-hindfoot scores, visual analog scale (VAS) scores, and Medical Outcomes Study Short Form 36-item questionnaire scores. All incisions healed primarily. A total of 106 patients were followed up for a minimum of 12 (range 12 to 72) months, with an average follow-up period of 27 months. The mean interval to fracture union was 14.5 (range 9 to 16) weeks. The mean American Orthopaedic Foot and Ankle Society ankle-hindfoot score at the latest follow-up visit was 91.4 (range 83 to 100) points. The mean visual analog scale score was 1.2 (range 0 to 6) points. The mean Short Form-36 score was 91.2 (range 80 to 96) points. Compared with the preoperative scores, all the 3 outcome measures had improved significantly postoperatively ($p < .05$). The postoperative stress radiographs did not reveal any ankle instability. None had evidence of post-traumatic arthritis of the ankle from the clinical examination and radiographs. A reasonable clinical evaluation and surgical repair was executed, with an appropriate repair technique chosen according to the site of deltoid ligament rupture. The results of the present multicenter study have shown that deltoid ligament rupture can be repaired in patients with an unstable medial ankle after fracture fixation and prevent ankle stabilization-related complications.

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Rupture of the deltoid ligament is commonly associated with ankle fractures. Hintermann et al (1) found that $\geq 40\%$ of ankle fractures had a deltoid ligament injury found on arthroscopic examination. Such injuries can be a source of persistent pain or pronation deformity (1). No randomized control trial has investigated the value of direct repair

of the deltoid complex when associated with an acute ankle fracture. Multiple studies have been published on the management of deltoid ligament injury using either conservative or surgical interventions. These studies have been limited in the number of patients evaluated and lacked objective outcome endpoints. To address these shortcomings, we undertook a multicenter, retrospective cohort study to delineate the effect of direct deltoid ligament primary repair at ankle fracture open reduction and internal fixation.

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Patients and Methods

Setting and Location of Data Collection

The institutional review board approved the present multicenter, retrospective, trial involving 4 cities (Shanghai, Dalian, Wuhan, and Hangzhou) in the east, north, and

west of China separately. From January 2006 to December 2011, 1533 operatively treated ankle fractures were identified. Of these, a ruptured deltoid ligament was identified in 131. All the authors collected the data from the 4 centers, and 2 of us (Z.M.Z. and Y.G.R.) completed the data analysis.

Inclusion Criteria

The inclusion criteria were patient age 16 to 70 years, a malleolar fracture with a deltoid ligament rupture or suspected rupture ("International Classification of Disease," 10th edition, codes for ankle fractures with deltoid ligament rupture include S82.4, S82.5, S82.6, S82.7, S82.8, and S93), a fracture that had occurred <3 weeks previously, no previous ankle fractures or abnormalities, no pathologic fracture, no neurovascular injury, no head injury, and no cognitive impairment. The patients included 74 males (56.5%) and 57 females (43.5%), with a median age of 33.2 (range 17 to 63) years (Table). The fractures were grouped according to the Lauge-Hansen classification scheme. The 131 fractures included 42 supination-external rotation type IV fractures (32.06%), 36 pronation-external rotation type III fractures (27.48%), 48 pronation-external rotation type IV fractures (36.64%), and 5 pronation-abduction type III fractures (3.82%). The fractures were also grouped using the AO/OTA system: 3 (2.29%) were 43-B2, 9 (6.87%) were 44-B2, 48 (36.64%) were 44-B3, 21 (16.03%) were 44-C1, 24 (18.32%) were 44-C2, and 26 (19.85%) were 44-C3. All the injuries were closed. Obvious swelling, ecchymosis, and tenderness were present at the medial malleoli in all cases. Anteroposterior, lateral, and mortise view radiographs were taken after injury. Three-dimensional computed tomography reconstruction can be very helpful for preoperative planning. The best imaging modality to define an injury to the medial ankle ligament complex is magnetic resonance imaging (MRI). An MRI scan was obtained for 96 of the present patients to evaluate the status of the medial ligamentous complex. Of those who had undergone MRI, 82 (85%) were found to have a complete deltoid rupture.

From the published data and our experience, operative repair of the deltoid complex is not necessary if the ankle is stable after fracture fixation. At our institutions and for the purposes of the present study, operative repair of the deltoid ligament complex was indicated if the medial clear space was >5 mm in distance on the mortise view. Talar subluxation was indicative of complete rupture of the deltoid ligament complex. Operative repair was also indicated if persistent medial ankle instability was evident on external rotation stress testing after fracture fixation. A medial clear space >1 mm after fracture fixation was considered indicative of entrapment of the medial soft tissue structures. Medial exploration with repair of the deltoid ligament was indicated. Ligamentous repair or reconstruction can be completed with either bone tunnels or anchors. A medial clear space of ≤1 mm during stress manipulation was considered a good result after surgery.

Operative Repair or Reconstruction of the Deltoid Ligament

An incision was made just below the medial malleolus and extended distally for 5 cm. The incision ran anterior to, but parallel with, the course of the posterior tibial tendon. The incision enabled evaluation of the posterior tibial tendon if necessary. The deep fascia was incised after retracting the posterior tibial tendon plantarily to expose the superficial and deep fibers of the deltoid ligament. The posterior vessels and nerve should be protected. To identify possible midsubstance tears, it was important to debride the adipose tissue from the surface of the ligament. If no midsubstance tear was identified, a longitudinal incision was made anterior to the medial malleolus to facilitate exposure of the anterior aspect of the superficial deltoid ligament complex. This ligamentous tissue could have avulsed from the malleolus. It can be approximated to

the bone or advanced using a suture anchor. Once the sutures from the anchor had been placed and appropriate tension applied, the surrounding soft tissues were imbricated to provide additional support. It is important to create a proper environment for healing by roughening the exposed area of the anterior medial malleolus using a rongeur. The portions of the superficial deltoid affected in this repair technique will include the anterior superficial tibiotalar and the tibionavicular and tibioligamentous fascicles.

If the deep ligament had been completely detached from its insertion on the talus, 2 anchors were placed on the medial aspect of talus. The sutures of the anchors should be tightened, maintaining the tension balance between the medial and lateral ankle ligaments. The superficial deltoid complex was repaired by direct suturing (Fig. 1).

Postoperative Care

The lower extremity was protected in a plaster cast for 3 to 4 weeks. Partial weightbearing was allowed as soon as the pain had decreased enough. Rehabilitation was started after the pain had resolved, with passive and active mobilization of the ankle joint, muscle training, and protection with a removable boot when walking. A walker or stabilizing shoes can be recommended for 4 weeks after plaster removal, depending on the muscle balance of the hindfoot. Afterward, we would recommend its use for walking on uneven ground and professional work outdoors. Full weightbearing was allowed once the fractures had healed.

Outcome Assessment

The outcome measures included fracture union, functional status, patient satisfaction, and complications. The patients were examined at 3 and 6 weeks and 3, 6, and 12 months postoperatively. At the follow-up examination, the patients were evaluated objectively and subjectively. Plain radiographs, including anteroposterior, lateral, and mortise views, were obtained immediately after surgery and at the final evaluation. The medial clear space was measured and compared with that of the uninjured ankle. A good rating was allowed only if no widening was evident. Valgus stress radiographs with the ankle in neutral flexion were obtained for 106 patients (80.9%) at the final follow-up evaluation. Stress was applied by a vigorous eversion force manually to the heel and midfoot. Any evidence of talar tilting was noted.

Fracture union was defined as complete cortical bridging between the proximal and distal fragments on 3-dimensional computed tomography scans. The functional assessment included evaluation of the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale (2,3) and completion of the Medical Outcomes Short Form 36-item questionnaire (SF-36) (4). The clinical outcomes were evaluated using the visual analog scale (VAS) for pain (5). Patient satisfaction was evaluated using a questionnaire. A summary of the outcome assessments is presented in Fig. 2.

Statistical Analysis

Statistical analysis was performed using SPSS software, version 14.0 (IBM Corp., Armonk, NY). Differences between the treatment groups were evaluated using the Student *t* test for continuous data and the chi-square or Fisher exact test for categorical data. All tests were 2-tailed. The level of significance was set at $p \leq .05$.

Results

Most of the patients were male and had sustained their ankle injury in falls, traffic accidents, collision sports, or bicycling or motorcycling accidents (Table). No significant differences were found in the demographic features or injury patterns between the 2 groups.

A total of 106 patients (81%) were followed up for an average of 27 (range 12 to 72) months. The mean interval to fracture healing was 14.5 (range 9 to 16) weeks according to the radiographic findings. The initial reduction of the medial clear space was rated as good. In all patients with follow-up data available, the medial clear space was <1 mm on radiographic evaluation. Furthermore, on the radiographs, no evidence of valgus tilting of the talus was seen in any patient with follow-up data available. The average AOFAS score was 93.4 (range 83 to 100) points at the last visit. The mean VAS score was 1.2 (range 0 to 6) points. The mean SF-36 score was 79 (range 65 to 91) points. Compared with the preoperative values, significant improvement was seen in all 3 outcome measures after operative intervention (Fig. 2).

In the present study, the location of the deltoid ligament ruptures was comparable with that in a previous biomechanical study (6). Of the 131 cases, 69 (52.67%) were avulsed from the talar insertion, 37 (28.24%) were a midsubstance rupture, and 25 (19.08%) revealed ligamentous injury at the medial malleolus insertion. No cases of clinical or radiographic ankle instability were present postoperatively.

Table

Demographic data and injury details stratified by treatment group (n = 131)

Parameter	Value
Age (y)	
Mean	33.2
Range	17 to 63
Gender (n)	
Male	74 (56.5)
Female	57 (43.5)
Side of injury (n)	
Left	56 (42.7)
Right	75 (57.3)
Mechanism of injury (n)	
Simple fall	36 (27.5)
Road traffic accident	29 (22.1)
Sports	35 (26.7)
Bicycle or motorcycle	18 (13.8)
Other	13 (9.9)
Smoking status (n)	
Smoker	84 (64.1)
Nonsmoker	47 (35.9)

Data in parentheses are percentages.

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