



Original Article

Early and mid-term results of transarticular external fixation in the treatment of supination-external rotation type IV equivalent ankle fractures

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ABSTRACT

Purpose: To investigate the early and mid-term results of open reduction and internal fixation (ORIF) with transarticular external fixation (TEF) but no deltoid ligament repair (DLR) in the treatment of supination-external rotation type IV equivalent (SER IV E) ankle fractures (AO/OTA classification 44-B 3.1) and provide evidence for clinical practice.

Methods: This study cohort consisted of 22 patients with SER IV E ankle fractures that underwent ORIF with TEF but no DLR between December 2011 and December 2014. There were 13 males and 9 females, mean age 38.9 years (range, 17–73 years). Eight cases involved the left side and 14 the right side. The causes of fractures included road traffic accidents (11 cases), falling from height (6 cases) and sports injuries (5 cases). The mean period of hospitalization was 9.8 days (range, 6–14 days). For all the patients, MRI and three-dimensional CT were done before surgery and X-rays done preoperatively and during follow-ups. The external frame was kept for 8–10 weeks. The preoperative American Orthopedic Foot and Ankle Society (AOFAS) ankle-hindfoot score was 56.86 ± 4.400 , the Medical Outcomes Short Form 36-item (SF-36) questionnaire score was 57.41 ± 4.102 and the visual analog score (VAS) was 5.50 ± 1.058 . Patients' main complaints about inconvenience of daily life were also recorded.

Results: All the 22 patients were followed up for 24–63 months (mean, 33.6 months). None of them developed nonunion during the follow-up; pin site infection was observed in one patient and posttraumatic osteoarthritis in another. At the final follow-up, the average AOFAS score, SF-36 score and VAS score were respectively 90.59 ± 5.096 , 79.59 ± 5.394 and 1.82 ± 1.181 , which were significantly improved compared with the preoperative data ($t = 26.221, p < 0.001$; $t = 11.910, p < 0.001$; $t = 11.571, p < 0.001$). The therapeutic effect was excellent in 13 cases, good in 7 cases and fair in 2 cases, with a good-excellent rate of 90.9%. Patients' main complaints were inconvenience of clothing (17 cases) and extremity cleaning (5 cases).

Conclusion: In the treatment of SER IV E ankle fractures, ORIF with TEF but no DLR can achieve satisfactory outcome, but long-term effect should be confirmed by large sample randomized controlled trials. © 2018 Chinese Medical Association. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND licence (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Supination external rotation (SER) fractures are the most common ankle fractures in clinic.^{1–3} SER type IV ankle fractures without medial malleolus fragment represent a trimalleolar equivalent ankle fracture of the lateral and posterior malleolus and an injury to the deltoid ligament (AO/OTA classification 44-B3.1). This kind of

SER type IV equivalent (SER IV E) ankle fractures are among the most unstable ankle fractures and require surgical treatment.^{3–6} Up to now, there is still controversy over the treatment for ankle fractures with deltoid ligament injury. No large sample randomized control trials have compared the effect with or without direct deltoid ligament repair (DLR) when associated with an acute ankle fracture.

Some studies suggested that routine DLR was not necessary in ankle fractures as it did not seem to improve clinical results and may lead to a worse long-term outcome.^{2,7–10} In the cases without DLR, although plaster casts were commonly used for postoperative external fixation, there are risks of ligament injury during every

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process of fixation and unfavorable factors for soft tissue care.^{2,4,11} It was accepted that transarticular external fixators play a fundamental role in the treatment of ankle fracture dislocations, which not only promote ankle stabilization but also improve soft tissue healing, therefore may be a good substitute for plaster casts.^{11–13} The application of transarticular external fixators could also offer an opportunity for deltoid ligament healing.

This study retrospectively analyzed 22 patients with SER IV E ankle fractures (AO/OTA classification 44-B3.1) treated in West China Hospital, Sichuan University between December 2011 and December 2014, by ORIF with transarticular external fixation (TEF) but no DLR. We aimed to evaluate the effect of ORIF with TEF and provide evidence for future practice.

Methods

Inclusion and exclusion criteria

The inclusion criteria included surgery of ORIF with TEF, examinations of preoperative MRI & three-dimensional CT and pre- and postoperative X-ray scan, and age > 16 years. Exclusion criteria were non-SER IV E ankle fractures, multiple fractures, open fractures, severe systemic disease, previous ankle injuries and deformities, age < 16 years, incomplete clinical or radiographic follow-up materials.

Baseline data

From December 2011 to December 2014, 22 patients met the exclusion and inclusion criteria and were enrolled in this study. There were 13 males and 9 females with an average age of 38.9 years (range, 17–73 years). Eight cases were affected on the left side, and 14 on the right side. The causes of fractures included road traffic accidents (11 cases), falling from height (6 cases) and sports injuries (5 cases). All

the patients underwent preoperative MRI and three-dimensional CT, while X-ray was conducted before surgery and during follow-up.

Surgical technique

Patients were positioned in supine position; a tourniquet was placed on the proximal thigh. A 10-cm longitudinal incision lateral to the fibula was made. After cutting the subcutaneous tissue and fascia layers, a blunt dissection was made to expose the fracture site of the fibula. Scar tissue was removed and anatomic reduction was performed to restore fibular rotation and length. A reconstruction bone plate of appropriate length was attached to the lateral side of the fibula using screws. The space between the peroneus brevis and the soleus muscle was dissociated to expose the posterior malleolar fractures. One or two cannulated screws were used to fix the posterior malleolus. The external rotation stress test was performed again to confirm ankle stability. The syndesmosis was assessed intraoperatively using a previously described, standard method for syndesmosis injury; surgical fixation was performed if needed.^{14,15} C-arm examination was used to confirm the appropriate reduction and internal fixation of fractures. Then the incision was closed in layers. After lateral and posterior malleolus ORIF and syndesmotic fixation, two Schanz nails were placed in the middle of the tibia, one in the calcaneus and one in the first metatarsus. Then the external fixator was connected and adjusted, and the ankle joint was maintained at the neutral position. C-arm examination was used to confirm appropriate position of internal fixation and Schanz nailing (Fig. 1).

Postoperative care

After operation, the external frame was kept for 8–10 weeks. Muscle training and mobilization of the interphalangeal joint of toe was started soon after operation; passive and active mobilization of the ankle joint was initiated when the external frame was removed.

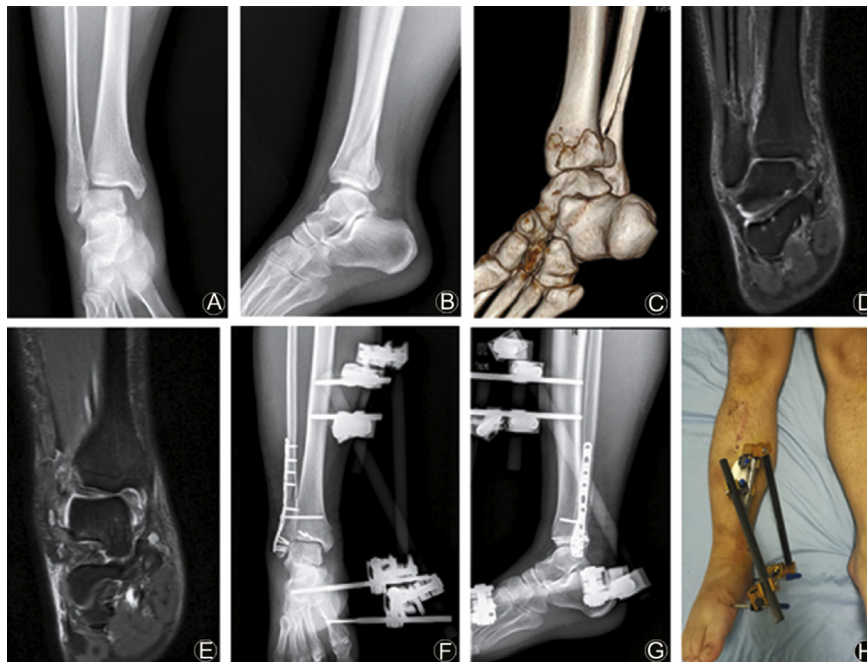


Fig. 1. Imaging studies of a 24-year-old patient with SER IV E ankle fractures (AO/OTA classification 44-B3.1) who underwent ORIF with TEF. **A–C:** Preoperative X-rays and three-dimensional CT; **D, E:** Preoperative MRI showing deltoid ligament injury; **F, G:** Postoperative anteroposterior and lateral X-rays; **H:** Postoperative appearance of the affected extremity.

Partial weight bearing was allowed at 4–6 weeks after operation. Full weight bearing was allowed when there was sufficient radiographic evidence of fracture healing.

Outcome assessment

Patients' outcome was measured by radiographic findings, functional assessments and complications. The main complaints about inconvenience of daily life were also considered. Radiographic findings can help diagnose fracture union and post-traumatic ankle arthritis. Functional assessment was performed using the American Orthopedic Foot and Ankle Society (AOFAS) ankle-hindfoot score, the Medical Outcomes Short Form 36-item (SF-36) questionnaire score, and the visual analog score (VAS).

Statistical analysis

Statistical analysis was performed using SPSS statistics version 24.0 software (SPSS Inc, Chicago, Illinois). All data were expressed as mean value \pm standard deviation (SD). The AOFAS score, SF-36 score and VAS score were compared by using paired *t*-test; the α value was set at 0.05. *p* value of less than 0.05 was considered statistically significant.

Results

All the 22 patients were followed up for 24–63 months (mean, 33.6 months). At the final follow-up, the average AOFAS score, SF-36 score and VAS score were improved significantly after operation (all $p < 0.001$, Table 1).

According to the AOFAS score, the treatment effect was excellent in 13 cases, good in 7 cases, and fair in 2 cases, with a good-excellent rate of 90.9%. There is no poor result. During follow-up, pin site infection attacked one patient which healed after wound dressing. No cases of clinical or radiographic ankle instability were present. On the final radiographs, no evidence of bone nonunion was seen. Posttraumatic ankle osteoarthritis was found in one female patient who had mild pain for two months. Conservative treatment and continuous follow-up were suggested for her. Patients' main complaints were inconvenience of clothing (17 cases) and extremity cleaning (5 cases).

Discussion

Controversy on DLR

The deltoid ligament is the primary restraint to posterior translation of the talus, with a relative contribution ranging from 50% to 80%.¹⁶ When the deltoid ligament is ruptured, lateral talar shift occurs and the distance between the medial malleolus and the medial surface of the talus (the medial clear space) widens. A medial clear space of >4 mm is usually considered to be abnormal.^{4,16,17} Such misalignment will alter ankle joint mechanics which could result in peritalar deformity and ankle mortise instability and arouse degeneration of the ankle joint and development of osteoarthritis.^{6,7,16}

Table 1

Pre- and postoperative AOFAS score, SF-36 score and VAS score.

Functional assessment	Preoperative	Final follow-up	<i>t</i> value	<i>p</i> value
AOFAS score	56.86 \pm 4.400	90.59 \pm 5.096	26.221	<0.001
SF-36 score	57.41 \pm 4.102	79.59 \pm 5.394	11.910	<0.001
VAS score	5.50 \pm 1.058	1.82 \pm 1.181	11.571	<0.001

However, ankle fracture fixation remains a controversial topic: whether a ruptured deltoid ligament associated with a fracture of the malleolus should be repaired is still discussed. No large sample randomized control trial has compared the effect with or without direct DLR when associated with an acute ankle fracture.

Some studies suggested that routine DLR was not necessary in ankle fractures as it did not seem to improve clinical results and may lead to a worse long-term outcome.^{2,7–10} Stromsoe et al¹⁰ designed a randomized controlled trial to examine the influence of the repair of a ruptured deltoid ligament. There were no differences between two groups in regard to symptoms and clinical findings: all the radiographs showed normal fracture healing. de Souza et al⁹ reported 22 patients with rupture of the deep deltoid ligament who were treated with internal fixation of the fibula but no direct repair of the deltoid and found that all patients had satisfactory outcomes. In the study of Baird and Jackson,⁸ 21 patients were treated without deltoid ligament repair and the result was good or excellent in 90% of patients; 3 patients who underwent repair had less favorable outcomes.

Other studies suggested that non-DLR may cause chronic ankle instability and secondary pain, while DLR could reduce long-term complications.^{3,18,19} Harper¹⁸ suggested that there was no need to repair the deltoid ligament if anatomic fixation of the fibula has been performed and the medial joint space maintained, but some patients were found suffered from loss of joint space reduction at the final follow-up. Johnson and Hill¹⁹ reported that in 29 patients of lateral malleolar fractures with deltoid ligament rupture treated without DLR, 10 patients had residual pain and 18 patients had medial ligament tenderness. Jones and Nunley³ suggested that lateral malleolus ORIF with DLR demonstrated favorable outcomes that were comparable with lateral malleolus ORIF with syndesmotic fixation for bimalleolar equivalent ankle fractures.

In the present study, DLR was not performed. For functional recovery and pain relief, significant improvement was achieved in AOFAS, SF-36 and VAS scores after operative intervention. Regarding the AOFAS score, the result was excellent in 13 cases, good in 7 cases and fair in 2 cases, with a good-excellent rate of 90.9%. There were no cases of bone nonunion and only one case of post-traumatic arthritis. So, ORIF with TEF can provide favorable functional results and pain relief.

Transarticular external fixators for ankle fractures

As mentioned previously, plaster casts are commonly used for postoperative external fixation in the cases without DLR. But plaster casts combine the risks of ligament injury during every process of fixation, loss of reduction following decrease in oedema and difficulties in the evaluation and care of the soft tissues. Moreover the plaster cast itself could also cause further skin and soft tissue injuries.^{2,4,11} It is accepted that transarticular external fixators play a fundamental role in the treatment of ankle fracture dislocations not only in ankle stabilization and comfort promotion, but also in soft tissue healing improvement, and therefore may be a good substitute for plaster casts.^{11–13} In this study, the external fixator created an open space above the skin, and five patients thought it sometimes difficult to clean the skin beneath the fixator.

As the application of transarticular external fixator after ORIF could provide additional stability and rigid fixation and an opportunity for deltoid ligament healing, early weight bearing is also allowed. Weight bearing protocols should optimize fracture healing; biomechanical and animal studies indicate that early loading is beneficial.²⁰ Pavolini et al²¹ reviewed the clinical results of 332 fractures treated with Ilizarov external fixator between 1984 and 1993. They suggested that Ilizarov external fixation is indicated the best for tibial fractures because of the advantage of allowing early

weight bearing, and also best for open fractures, comminuted fractures, intra-articular fractures and fractures with bony defect.

However, transarticular external fixators usually cost more money and may bring particular inconvenience for patients. In this study, although patients do not need to take the plaster cast on or off repeatedly, 17 of 22 patients thought it is inconvenient because they need special trousers to accommodate the extra space occupied by the external fixator.

Complications

In the present study, only one patient developed pin site infection and was healed after wound dressing. TEF and non-DLR may bring convenience for wound care. Firstly, there is no process of creating an incision over the medial malleolus to perform DLR. The soft tissue around the medial malleolus is a vulnerable layer of skin that is prone to wound healing problems. Secondly, there is no use of plaster casts which may bring some bad effects for wound healing and transarticular external fixators are especially used for fractures with poor soft tissue conditions. Posttraumatic ankle osteoarthritis is a common long-term complication after fractures and ligament injury.²² For early stage traumatic ankle osteoarthritis, conservative treatment is firstly used. It is consensus on the joint sacrificing procedures including total ankle replacement or ankle arthrodesis for the treatment of painful end-staged ankle osteoarthritis.^{22–24} In this study, as the patient's symptom was not severe and the duration was short, we suggested her to take conservative treatment and continuous follow-up.

Conclusion

There is still controversy over the treatment for ankle fractures with deltoid ligament injury. According to previous studies and the present study, satisfactory results were seen in most of the patients without DLR. Regardless of fixation strategies, the ultimate goal is to make patients able to return to their preinjury activities quickly and painlessly and minimize the incidence of postoperative traumatic arthritis.^{1,25,26} In conclusion, ORIF with TEF but no DLR can obtain satisfactory effectiveness to manage SER IV E ankle fractures (AO/OTA classification 44-B3.1) and is also convenient for wound care. This study has limitations, such as the limited number of cases and the short follow-up period. Prospective randomized controlled trials involving more samples are needed to confirm the results of this study.

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