TRADITIONAL CHINESE MEDICINE IN ORTHOPAEDICS

Closed Reduction for the Treatment of Grade IV Supination-External Rotation Fracture of the Ankle Joint: A Retrospective Analysis

Hong-zhou Zhao, MBBS[1], Tong-shun Fan, MBBS[1], Shu-li Wang, MD[2], Li-min Liu, MBBS[1], Ming-jun Liu, MBBS[1], Jia-hui Xing, MD[1]

[1]*Reduction Room of Orthopedics and Traumatology Department of Integrated Traditional Chinese and Western Medicine and* [2]*Imaging Department, Tianjin Hospital, Tianjin, China*

Objective: To investigate the curative effect of closed reduction and external fixation in the treatment of grade IV supination-external rotation fractures of the ankle joint.

Methods: Fifty-six patients treated with closed reduction and external fixation from February 2016 to March 2020 were included in this retrospective study, all with sprains. After receiving nerve block anesthesia, the patient underwent closed reduction under C-arm fluoroscopy, and the ankle joint was fixed in a dorsiflexion-inversion position with casting and splints after the end of the fracture met the reduction standard by fluoroscopy. One week and four weeks after the reduction treatment, oblique axial and coronal MR scans of the ankle joint were performed to determine the degree of injury and healing of the inferior tibiofibular syndesmosis; anteroposterior and lateral X-rays of the ankle joint (including the ankle acupoints) were regularly reviewed to observe the fracture alignment and healing. Combined with the images and physical examination, the patients were instructed to undergo ankle weight-bearing rehabilitation training when they met the clinical healing standard, and at the last follow-up, the Mazur ankle evaluation and grading system were used for evaluation. After the reduction, the images were evaluated according to the Leeds standard. The image healing of fracture was evaluated by callus growth criteria.

Results: The follow-up period of patients ranged from 11 to 58 months, with an average of 26.8 months. The clinical healing time was (8.51 ± 2.12) weeks. The excellent and good rating after reduction was 82.1%, and the excellent and good rating during clinical fracture healing was 73.2%, according to the Leeds imaging evaluation. According to the Mazur ankle evaluation and grading system, the excellent and good rating was 75.0%. Pairwise comparison of callus images at 4, 6 and 12 weeks showed statistically significant differences ($P < 0.05$), suggesting callus growth at different time periods. A total of 56 patients had anterior inferior tibial fibular ligament (AITFL) injuries (grade I-III), among which 11 patients had AITFL injuries combined with grade II injuries of the interosseous ligament (IOL) and 4 patients had AITFL injuries combined with grade III injuries of the IOL.

Conclusions: Most of the patients with grade IV supination-external rotation fracture of the ankle joint had good prognosis after closed reduction and plaster combined with splint fixation. For patients with IOL injury who had poor prognosis, open reduction and internal fixation therapy is appropriate.

Key words: Fracture of the ankle joint; Grade IV supination-external rotation; Inferior tibiofibular syndesmosis; MR; Plaster combined with splint

Introduction

The ankle joint is the flexion joint that bears the largest amount of weight in the human body, carrying about five times a person's body weight while walking[1]. Fracture of the ankle joint is a common intra-articular fracture, occurring most often in young adults and accounting for 3.92% of

Address for correspondence: Jia-hui Xing, Reduction Room of Orthopedics and Traumatology Department of Integrated Traditional Chinese and Western Medicine, Tianjin Hospital, Jie Fang Nan Road, Tianjin, China 300210 Tel: 022-60123053; Email: 774706047@qq.com

Disclosure: There are no funders to report for this submission.

Received 17 April 2021; accepted 26 May 2021

Orthopaedic Surgery 2021;13:2163–2169 • DOI: 10.1111/os.13115

total body fractures. At present, the Lauge-Hansen classification is the most commonly used classification in fracture of the ankle joint, and supination-external rotation is one of the most common classifications, accounting for about 40%–70% in fractures of the ankle joint, and most of them being intra-articular fractures. Improper treatment is likely to cause complications such as fracture malunion and traumatic arthritis, with limited ankle function, affecting the quality of a patient's life and work.

The aim of the treatment of ankle joint fractures is to restore the anatomic alignment, alignment of the lateral malleolus and the integrity of the weight-bearing joint surface, to maintain the stability of the ankle joint and to restore its mobility. For patients with grade IV supination-external rotation fracture of the ankle joint, the current clinical treatment is mainly open reduction and internal fixation, which can effectively restore the anatomic alignment of the fracture end and maintain the fixation so as to facilitate patients' carrying out early functional rehabilitation training. The cost of surgical treatment is high, and a surgical scar will be present. Other complications include infection at the site of incision. Some patients cannot undergo surgical procedures because of medical conditions, psychological reasons or medication and other factors. They also need a more appropriate and effective treatment to return to life and work after treatment. Compared with surgical treatment, conservative treatment has the advantages of less trauma, less damage to the soft tissue around and blood supply at the end of the fracture, is good for fracture healing, lowers the economic burden, and averts the need of a second surgery, all of which are favorable factors for patients.

Guozhu Zhang *et al.* followed up on 43 patients with supination-external rotation fractures and found that the conservative treatment effect on the patients with posterior malleolus fracture mass greater than 25% of the distal articular surface of the tibia was not satisfactory[2]. In our department, most of the patients with grade IV supination-external rotation caused by simple sprain injury and the fracture mass of the posterior ankle is less than 25% of the articular surface have a good prognosis after the treatment of closed reduction and external fixation. The reduction technique is light and handy to avoid the aggravation of local injury by an intrusive operation. This study aimed to retrospectively evaluate the prognosis of patients with imaging and ankle function, so as to analyze the prognostic related factors of fracture. At present, only a few hospitals in China have closed reduction and external treatment for patients with grade IV ankle supination and external rotation fractures, and the conditions across these institutions are inconsistent without a unified treatment standard. Our department has decades of clinical experience in the treatment of such fractures with the standard reduction technique and casting combined with splint external fixation in a special position for the ankle joint, and most patients have been observed to obtain better long-term results. The purpose of this study is to: (i) summarize the related factors of prognosis; (ii) describe the reduction and fixation process and standards; and (iii) promote clinical application by orthopedics doctors. MR of the ankle joint was used to determine the injury of the inferior tibiofibular syndesmosis injury, observe the relationship between ligament injury and the prognosis for healing of the fracture.

Materials and Methods

Basic Information

A total of 56 patients with grade IV supination-external rotation fracture of the ankle joint were treated by closed reduction and inversion casting combined with splint external fixation in our department from February 2016 to March 2020. Twenty-five male patients and 31 female patients ranged in age from 26 to 65 years old, with an average age of 46.2 years old. The cause of injury was a sprain, and the consultation time after injury was 1 h to 4 days, with an average of 7.5 h. There were 36 left ankle cases, 20 right ankle cases, and 52 cases of tibial talar joint dislocation. Routine examinations were completed before the closed reduction, and the internal organs and soft tissue conditions of the affected limb were evaluated. After contraindications for the closed reduction were removed, the patients underwent closed reduction under C-arm fluoroscopy, and their ankle joints were positioned through the use of casting combined with splints after meeting the standard of functional reduction. The fixation period was 42–56 days, with an average of 48.7 days. Patients' X-rays were reexamined at 1, 2, 4, 6, and 12 weeks after closed reduction. MR examinations of the ankle joint (including oblique axial and coronal MR scans) were performed at week 1 and week 4 respectively, and follow-up was completed. This study was approved by the Medical Ethics Committee of the Tianjin Hospital (Ethics Code: 2021 Medical Ethics Review 014).

Inclusion Criteria

According to the Lauge-Hansen classification: (i) the patient was diagnosed with grade IV supination-external rotation injury; (ii) patients were treated with closed reduction and external fixation; (iii) had received imaging diagnosis, reexamination and follow-up; (iv) had Mazur Ankle Scores, Leeds imaging evaluation criteria, callus growth criteria, ankle MR; and (v) retrospective study.

Exclusion Criteria

These were: (i) pathological fracture; (ii) posterior malleolus fracture exceeds 25% of the inferior articular surface of the tibia; (iii) open fracture; (iv) anesthesia or closed reduction should not be performed with severe medical complications; and (v) incomplete or lost medical records.

Reduction Method

After satisfactory femoral nerve anesthesia combined with sciatic nerve anesthesia, the patient was in the supine position, flexing the knee joint. One assistant held the proximal leg with both hands, and the other assistant held the foot to

maintain the neutral position of the leg. Traction along the direction of the fracture misalignment (traction force should not be too great to avoid aggravating the injury) (Fig. 1A).

The assistant rotated the foot, and the operator pressed the fracture block of distal fibula with both hands and thumbs; the other fingers held the distal tibia pulling the tibia to the outside, and then pressed the fibula fracture block inward. The assistant then turned inward and extended the ankle joint back to correct the dislocation and fibular displacement (Fig. 1B). The operator held the front of the distal tibia and pulled down with both hands, then pressed the fracture block of the posterior ankle and the outer ankle upward with both hands and thumbs up (Fig. 1C). Squeezed the inner ankle bone block upward (Fig. 1D) and maintained the fixation of the ankle rotation inversion back to the extension position.

Fixation Method

The above position was maintained, and the plantar part of the foot and the back of the leg were fixed with a 7.5 cm wide cast from 2 cm below the fibula head to 1 cm beyond the toes. After shaping the cast, it was combined with the inversion splint for fixation. After 6 weeks, the splints were removed according to the healing process of the fracture as evidenced by the X-ray.

Reduction Standard

There was no lateral displacement on the X-ray of the ankle mortise, and the medial space between the talus and the medial malleolus was normal. The inferior tibiofibular space was 2–4 mm or equal to the healthy side. The lateral images showed the anterior and posterior displacement of the medial and lateral malleolus to be <2 mm, and the step of the posterior ankle joint to be <2 mm.

Functional Training

After the reduction, the patient began the isometric contraction of the quadriceps femoris, tibialis anterior muscle, gastrocnemius muscle, and extension-flexion of the toes. On the second day, passive hip flexion and knee flexion were performed. After 6 weeks, according to the progress of healing of the fracture, the cast and splints were removed and partial weight-bearing functional rehabilitation training was performed. Full weight bearing functional rehabilitation training was performed approximately 8 weeks later.

Therapeutic Evaluation

The image data were measured by the CARESTREAM Vue PACS film reading system (Carestream Corporation, Toronto, Canada). Imaging evaluation of ankle joint reduction (X-ray) was conducted according to the Leeds standard, and the displacement distances of the medial, external, and posterior malleolus, the space between the talus and medial malleolus, and the space between the inferior tibiofibular joints were measured and compared with the healthy side to evaluate the reduction effect. The Mazur Ankle Score was used to evaluate patients' pain, gait, range of motion of the ankle, and whether analgesic medication for fracture complications such as traumatic arthritis was needed. The healing of the end of the fracture was determined by the callus growth standard of the end of the fracture in the X-ray, including the shape of the edge of the end of the fracture, callus edge shape, callus quantity, callus density, etc.

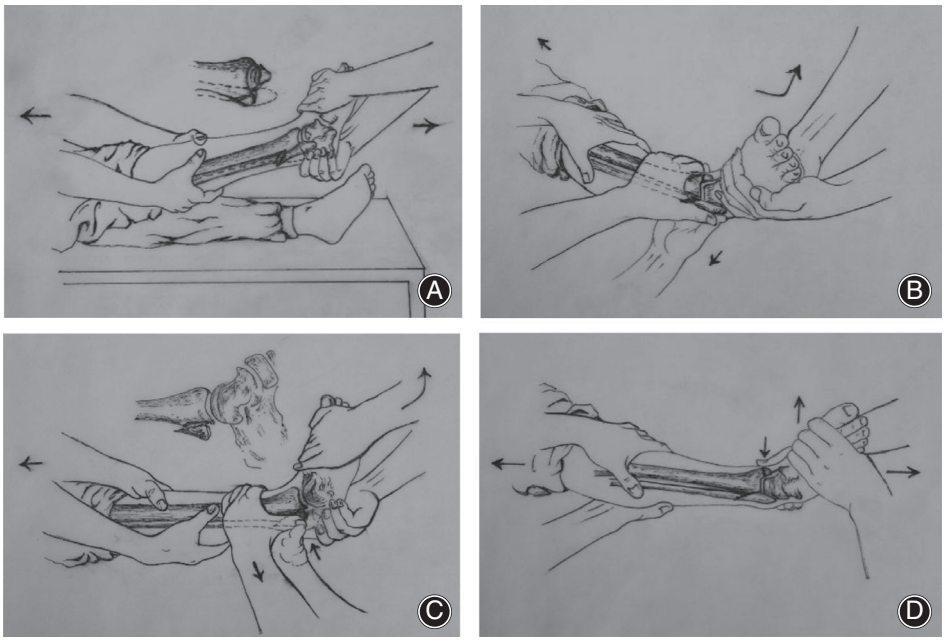

Fig. 1 (A) correction of external rotation. (B) correction of talus and lateral malleolus moving outward. (C) correction of posterior ankle proximal. (D) correction of medial displacement—malleolus separation and displacement.

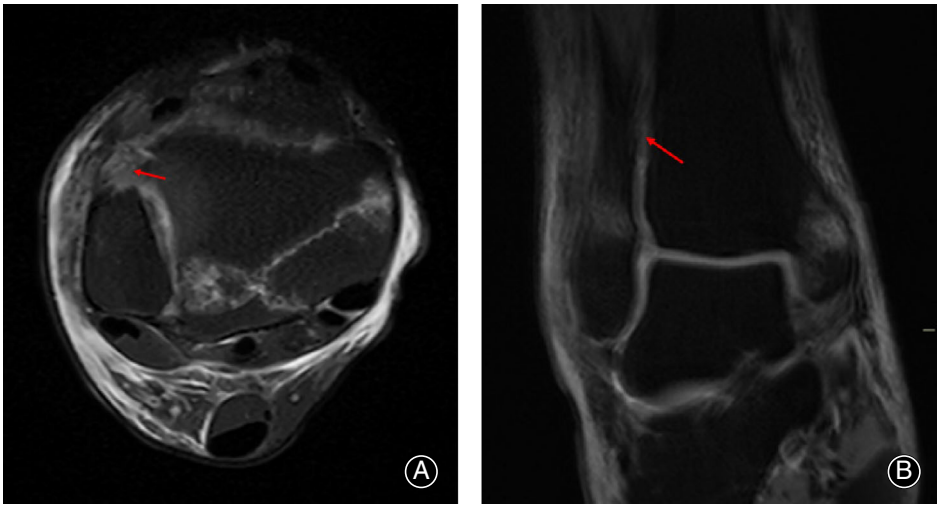

Fig. 2 A 36-year-old female patient who had an ankle MR examination one week after reduction showing AITFL rupture on oblique axial T2WI (A) and continuous IOL on coronal T2WI (B).

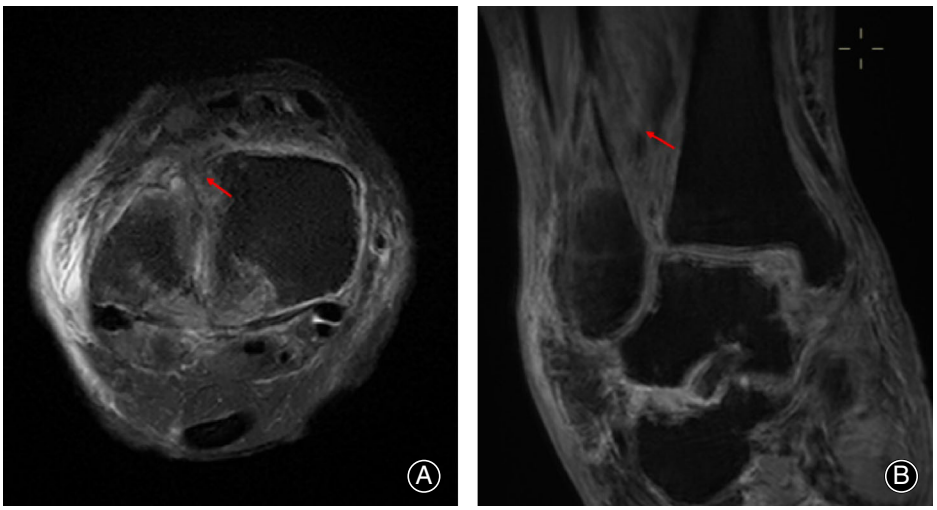

Fig. 3 A 47-year-old male patient who had an ankle MR examination 4 weeks after reduction showing scar repair after rupture of AITFL on oblique axial T2WI (A) and scar repair after rupture of IOL on coronal T2WI (B).

Statistical Analysis

SPSS (IBM, Armonk, NY, USA) version 20.0 was used for the statistical analysis. The recovery time of joint function, Mazur score, callus score and clinical healing period belongs to measurement data. Mazur score and callus score both met the normal distribution. T-test was used to compare the score of callus growth in different periods. $P < 0.05$ was defined as statistically significant.

Results

General Results

The follow-up period of patients was 11–58 months, with an average of 26.8 months, and the recovery time of joint function was 71.37 ± 4.29 days. According to the relevant standards of Surgery, the clinical healing period of fracture was 8.51 ± 2.12 weeks.

Mazur Standard

The function and symptoms of ankle joint were evaluated by the Mazur standard: 27 excellent cases, 15 good cases, eight fair cases, and six poor cases; the excellent and good rating was 75.0%. The pain symptom score was 42.83 ± 4.26; gait score was 31.56 ± 4.81; ankle joint plantar flexion-dorsiflexion range of motion score was 8.65 ± 1.07. 8 patients occasionally required non-steroidal anti-inflammatory drugs (NSAIDs) for analgesia.

Imaging Outcomes

Leeds Standard

Imaging evaluation was carried out according to the Leeds standard. After the reduction, there were 46 excellent cases, five fair cases and five poor cases, with an excellent and good rating of 82.1%. In the clinical healing of the fracture, 41 cases were excellent, 10 cases were fair, five cases were poor, and the excellent and good rating was 73.2%. There were five patients with

Fig. 4 A 28-year-old female patient with X-ray of ankle joint showing displacement of internal, external, and posterior malleolus fractures with tibial talar joint dislocation (A). After emergency closed reduction and fixation, C-arm fluoroscopy showed that the dislocation of the ankle was corrected and the fracture was restored to anatomic alignment (B). The trabeculae passed through the fracture site at follow-up 2 years later, and the fracture had bony union (C).

displacement of the fractures, four of whom had Grade III injury of the AITFL and IOL in MR of the ankle joint. There was one case of an AITFL grade III combined with an IOL grade II injury.

Callus Growth Criteria

The growth of the fracture end was based on the callus growth criteria, 4 w: 1.49 ± 0.43; 6 w: 2.81 ± 0.47; 12 w: 3.73 ± 0.21. T-test was used for intra-group comparison, and the pair comparison showed statistically significant difference ($P < 0.05$), suggesting callus growth at different time periods.

MR of the Ankle Joint

All 56 patients showed AITFL injury (grade II-III) in the ankle joint MR, including 11 patients with combined AITFL injuries grade II IOL injury (18.2% excellent and good rating on the Mazur Ankle Score Scale) (Fig. 2A,B) and four patients with combined grade III injury IOL (0% excellent and good rating on the Mazur Ankle Score Scale) (Fig. 3A, B). During the period from reduction to clinical healing, the inferior tibiofibular space widened in four patients with AITFL injury combined with grade III IOL injury, which was <2 mm compared with the healthy side. One patient with IOL grade II injury experienced medial and lateral malleolus displacement of 1.5 mm.

Complications

In the initial stage of treatment, three patients were found with i-degree pressure sores on the heel, which were improved after treatment. All patients experienced varying degrees of ankle stiffness, disuse osteoporosis and muscle atrophy. After the removal of the external fixation, patients began functional ankle exercises, and the above complications were resolved. Compared with open reduction and internal fixation with plates and screws, the cast combined with splint fixation is slightly less stable. If the patient's compliance was poor, the fracture was prone to displacement again. There was discomfort in the ankle joint during the inversion dorsiflexion fixation.

Six patients developed traumatic arthritis and occasionally needed to take non-steroidal anti-inflammatory drugs (NSAIDs) for analgesia. The posterior malleolus fracture fragment was measured to involve >10% of the weight-bearing articular surface. As the fractures healed, obvious bone decalcification could be seen on the X-ray in most patients. With weight-bearing rehabilitation training, the imaging manifestations of disuse osteoporosis were improved (Fig. 4).

Discussion

The anatomical structure of the ankle joint is complex, and fracture classification includes Lauge-Hansen, Weber *et al.*[3] The Lauge-Hansen classification is based on the position of the foot at the time of injury and the direction of force. The injury mechanism of different types of injury is clear, with adequate attention paid to the injury of ankle ligaments. This is consistent with the theory of "paying equal attention to muscle and bone" in traditional Chinese medicine. Through step-by-step analysis of the injury mechanism, the Lauge-Hansen classification can accurately guide the closed reduction treatment on fractures of the ankle joint and dislocation caused by indirect force. The authors think that definite classification diagnosis, effective reduction and fixation, and proper functional exercise are the elements for a conservative treatment plan on fractures of the ankle joint. The incidence of supination-external rotation fracture is the highest among the four types of fractures[4–6]. Most patients with this kind of fracture have relatively minor injuries of the syndesmosis tibiofibular syndesmosis, and effective external fixation after fracture reduction can maintain its stability, allowing it to be treated conservatively according to the methods described in this paper.

Compared with the shortcomings of invasive operation such as surgical scars of open surgery, the closed reduction and external fixation treatment is non-invasive, does not damage the blood supply of the affected area and does not remove the periosteum, which is conducive to fracture

healing. It furthermore has the advantages of less pain and low cost for patients. In this retrospective study, the majority of patients treated with closed reduction and external fixation had an accurate prognosis, and the incidence of traumatic arthritis was lower in those patients whose posterior malleolus fracture fragment involved less than 10% of the distal tibial weight-bearing articular surface.

In the reduction of supination-external rotation fractures, the reverse injury mechanism was adopted. The restoration was carried out in the order of lateral malleolus, posterior malleolus and medial malleolus while the fixation was maintained[7]. For patients with the posterior malleolus fracture fragment at less than 25% of the inferior articular surface of the tibia, this method can basically meet the standard of functional reduction in the treatment of fracture alignment. Some patients can even achieve anatomical alignment of the end of the fracture, with definite curative effect. Most of the tibial talar joint dislocation and fibular fractures could achieve anatomical alignment. The medial malleolus bone fragment was separated and displaced in patients with grade IV supination-external rotation fractures, and the deltoid ligament was relaxed when the ankle joint was inversion. The functional reduction standard of the fracture fragment could be satisfied by pressing upward. The ankle joint is extended back by squeezing the posterior malleolus fracture block, and the posterior malleolus fracture block is restrained through soft tissue on the posterior side of the tibia to limit its re-displacement.

As for the reduction and posterior fixation, we found that the stability of the ankle joint in the rotation-inversion-dorsiflexion position was better than that of the sole cast or splint. The patient's comfort and fixation strength were better than that of the "U" type plaster in the inverted position. The plaster was used to maintain the foot in the inversion-dorsiflexion position, and the cast combined with splints were used to maintain the talus in the pronation and pronation position. When the ankle is inverted, the lateral collateral ligament is strained and pulled, and the lateral malleolus fracture block forms a lever force effect with the tibia as the fulcrum; this is conducive to its alignment and the alignment of the end of the fracture. The medial deltoid ligament relaxes in the inversion position of the ankle to reduce longitudinal traction of the medial malleolus and prevent re-dissociation. The "L" plaster maintains the dorsiflexion of the ankle so that the wider articular surface of the anterior talus fornix matches the articular surface of the distal tibia. The dorsiflexion position strained the ankle capsule, and the posterior malleolus bone block was not easily shifted to the proximal end after being pulled by the joint capsule and restrained by the posterior tendon. Through repeated practice, we found that the use of casting combined with splint external fixation after reduction of supination and external rotation fracture is a more effective method. After reduction, the functional hip, knee, and toe exercises begin, thereby reducing the risk of joint stiffness, muscle atrophy, and venous thrombosis in the lower extremities due to immobilization, in addition to reducing limb swelling and promoting fracture healing. Before the removal of the cast and splints for functional exercises, color ultrasound examination of lower extremity veins should be performed to determine the presence of deep vein thrombosis.

Rammelt *et al.*[8] and Hoefnagels *et al.*[9] believed that IOL played a key role in maintaining the stability of the inferior tibiofibular syndesmosis. As long as the IOL was intact, the inferior tibiofibular syndesmosis would not separate, and any injury of two ligaments combining the IOL would lead to inferior tibiofibular syndesmosis separation. Oblique axial MR plain scan can clearly reflect the degree of injury. In this retrospective study, most patients with AITFL injuries did not have complete fracture of the IOL, and the patients with combined fracture of the IOL after reduction had poor alignment of fractures of the inferior tibiofibular space and lateral malleolus, resulting in poor prognosis and curative effect. It is recommended that the patient reexamine the MR of the ankle within 1 week of the emergency closed reduction and fixation to clarify the injuries of AITFL and IOL. If it is determined that there is a complete rupture of the IOL, open reduction and internal fixation are recommended. For other types of closed fractures of ankle joint with serious injuries and obvious deformities, emergency closed reduction should be required to correct misalignment, relieve ankle swelling, reduce the risk of vascular and nerve injury, and create conditions for surgery[10,11].

Limitations

In summary, there are few follow-up patients. We need to expand the sample size to summarize the long-term prognosis related factors. The follow-up period of some patients was shorter (<1 y), so the follow-up period can be extended to evaluate comprehensive recovery.

Conclusions

This study found that for patients with ankle grade IV supination and external rotation fractures, casting combined with splint external fixation after closed reduction has better long-term prognosis. Among them, the prognosis of patients with AITFL combined with complete rupture of IOL is poor, and surgical treatment should be performed after reduction and correction of misalignment.

References

1. Luo JC, Lian HY, Wang B, Wang ZG, Qiao M, Li B. The value of arthroscopy in the treatment of anterior ankle impingement. Shi Yong Gu Ke Za Zhi, 2011, 17: 759–760.
2. Zhang GZ, Wang MY. Conservative management of supination-eversion fractures of ankle. Zhong Hua Chuang Shang Gu Ke Za Zhi, 2006, 2006: 404–406.
3. Zhang RY, Yun C, Su P, Yang T, You XD. Locking compression hook plate versus tension band for simple distal lateral malleolus fracture. Zhong Guo Jiao Xing Wai Ke Za Zhi, 2019, 27: 107–110.
4. Zhu W, Qiu XS, Shi HF, Chen YX. The Epidemiological analysis of 1080 patients with ankle fractures. Shi Yong Gu Ke Za Zhi, 2018, 24: 230–233.
5. Tartaglione JP, Rosenbaum AJ, Abousayed M, DiPreta JA. Classifications in brief: Lauge-Hansen Classification of Ankle Fractures. Clin Orthop, 2015 Oct, 473: 3323–3328.
6. Wang Y, Shi L, Cao L, Wu WJ, Cui ZG. A X-ray analysis of 2196 ankle fractures cases in adults. Zhong Guo Lin Chuang Yi Xue Ying Xiang Za Zhi, 2017, 28: 354–358.

7. Bi HL, Zhang Q, Gu EP, Zhao HZ. Application of ladder tower pad in manipulative reduction and plaster support and splint external fixation in the treatment of supination external rotation ankle fracture. Zhong Yi Zheng Gu, 2019, 31: 62–65 +68.
8. Rammelt S, Zwipp H, Grass R. Injuries to the distal tibiofibular syndesmosis: an evidence-based approach to acute and chronic lesions. Foot Ankle Clin, 2008, 13: 611–633 vii-viii.
9. Hoefnagels EM, Waites MD, Wing ID, Belkoff SM, Swierstra BA. Biomechanical comparison of the interosseous tibiofibular ligament and the anterior tibiofibular ligament. Foot Ankle Int, 2007, 28: 602–604.
10. Li T, Sun ZJ, Chai YM, *et al*. Expert consensus on optimizing ankle fracture treatment based on ERAS concept. Zhong Hua Gu Yu Guan Jie Wai Ke Za Zhi, 2019, 12: 3–12.
11. Sun ZJ, Sun X, Sun WT, Gao ZQ, Li T, Wu XB. Expert opinions on optimized treatments of ankle and distal radius fractures in light of enhanced recovery after surgery. Zhong Hua Chuang Shang Gu Ke Za Zhi, 2019, 21: 864–868.