Effectiveness-Analysis of one-stage Operation for Combined Ankle Fracture and III Degree Lateral Ligament Injury: A Retrospective Study of 23 Cases

Chunquan Zhu
Wuhan University
Linglong Deng
Wuhan University
Chong Zhang
Wuhan University
Guorong Yu
Wuhan University Zhongnan Hospital
Li Yu (yzorthopedics@whu.edu.cn)
Wuhan University Zhongnan Hospital

Research

Keywords: Ankle joint, Bone fracture, Lateral ligament complex, Operative approach, One-stage operation

Posted Date: July 7th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-40100/v1

Abstract

Background: Ankle fracture is often accompanied by injuries of lateral collateral ligaments, which results in ankle instability and traumatic arthritis in the later period, causing pain and discomfort in patients. However, the repair of the lateral collateral ligament is still inconclusive. The aim of this study was to investigate the operative outcome of one-stage simultaneous repair of the foot and ankle fracture combined with the III grade injury of lateral ligament.

Methods: 15 males and 8 females (mean age 37.8 [10.5] years) underwent X-ray and CT scan to determine the type of fracture. MRI, Ultrasound and intraoperative fluoroscopic stress testing were applied to confirm the ligament injury. After the operative treatment of fracture, the ruptured ligament was repaired with suture anchor in 21 cases, meanwhile 1 case combined with chronic ankle instability was repaired with modified Broström-Gould method and another case with middle ligament rupture was applied with the InternalBrace approach. Routine postoperative X-rays and physical examination were carried out, and the American Orthopaedic Food & Ankle Society score was recorded to assess the function and the pain of the wounded ankle.

Results: After the operation, the range of ankle motion in all patients was improved, and the bone healing time of the patients was 6-24 (10.09±3.61) weeks. There was no chronic instability of lateral ankle or subtalar joint in all the cases. Moreover, 2 cases presented as cartilage lesions of the medial talus, and the micro-fracture surgery were performed one year later; 1 case suffered from subtalar arthritis, and underwent subtalar arthrodesis 14 months after operation. Furthermore, the patients' last follow-up AOFAS score was (83.70±4.69) points. There was no occurrence of adverse events and complications such as neurovascular injury, infection or delayed healing of operative incision.

Conclusions: One-stage simultaneous repair of the foot and ankle fracture combined with the III grade injury of lateral ligament contributes to the stability of ankle and subtalar joint, and improves the joint function of ankle. It proved to be safe and effective.

Background

The ankle joint, as the most weight-bearing hinge joint of human body, the pressure of it can be up to 2-5 times of the body weight when weight-bearing walking. If the traumatic energy is beyond endurance, it is easy to cause simultaneous damage to both the bone and the ligament of ankle joint[1].To restore the articular surface and the intactness of ankle, The orthopaedic surgeons usually pay more attention to the accurate reduction of the fracture, rather than the repair of ankle ligament, resulting in the chronic instability of the ankle joint in some patients after the injury, which leads to the occurrence of traumatic arthritis ultimately[2].

It's well known that more than 90% of the ankle ligaments injuries are lateral ligaments damage. 15% ~20% of the patients without timely operation demand operative intervention due to the chronic instability of the ankle joint. On the other hand, the clinical efficacy of nonoperative treatment for acute

lateral collateral ligament tear is comparable to that of operative treatment[3].Therefore, the early intervention for acute lateral collateral ligament tear is still controversial[4].From April 2015 to December 2016, a total of 23 patients with ankle fracture accompanied with lateral collateral ligament rupture had been admitted and treated in our department. After the anchor-suture repair of the ruptured anterior talofibular ligament (ATFL) and/or calcaneofibular ligament (CFL) at the same time of open reduction and fixation of the fracture, there was no case of chronic lateral instability of the ankle joint occurred during the follow-up, so it is reported as follows.

1. Methods

1.1 Cases inclusion and exclusion criteri *a*

Cases inclusion criteria: Patients with ankle fracture combined with CFL and/or ATFL rupture; Patients with simultaneous primary operation for the aforementioned injuries; Patients with lateral ankle ligament complex injury confirmed by MRI, ultrasound and intraoperative fluoroscopic stress testing; the follow-up time more than 2 years.

Cases exclusion criteria: patients with poor compliance; Patients with open injuries; patients with injuries of medial triangle ligament; Patients with incomplete follow-up data.

1.2 Participants

From April 2015 to December 2016, we continuously operated 23 patients, 15 males and 8 females aged from 8 to 65 years old (37.8 ± 10.5 on average), with ankle fracture combined with lateral collateral ligament injuries. The patients could be categorized into 3 groups, according to the injury factors: 5 cases of accident injuries; 6 cases of falling injuries; 12 cases of ankle sprain.

The specific injury types were demonstrated as below(Table 1).

Table 1
Patient Characteristic Data

Figure 2. Male, 19 years old. Avulsion fracture of talus with III degree ATFL & CFL injury for sports injury.

(2A) Preoperative X-ray showed avulsion fracture about 5 mm between talus and fibula. (2B) Transverse section MRI showed the ATFL rupture. (2C) Coronal section MRI showed CFL rupture and tendon sheath hydrocele of fibula brevis. (2D) Preoperative Ultrasound identified fracture fragment as a 5 mm hyperechoic area between talus and fibula. (2E) No obvious CFL echo was observed; Only Banded liquid dark area was observed (arrow); CFL was thicker about 3.5 mm in fibula side with poor tension. (2F, 2G) Anterior displacement about 12 mm and inclination about 20° for talus in intraoperative ankle stress testing; Visible fragment of avulsion fracture from talus (arrow). (2H) It showed CFL rupture from calcaneus and ATFL rupture from talus during the operation (arrow). After the fragment was cleared, the ligament was sutured and fixed with suture anchor. (2I) Postoperative X-ray showed the anchor was in good position.

	Bone Fracture / Dislocation	**Ligament Rupture**
3 cases	calcaneus fracture lateral malleolus fracture subtalar joint dislocation	CFL &ATFL rupture (3 cases)
3 cases	talus fracture and dislocation	CFL &ATFL rupture (2 cases) ATFL rupture (1 case)
7 cases	II degree of supination-abduction (SAB)	CFL &ATFL rupture (2 cases) ATFL rupture (*5 cases)
10 cases	lateral malleolus / talus avulsion fracture	CFL &ATFL rupture (6 cases) ATFL rupture (4cases)
*1 case with chronic lateral instability of ankle in 5cases;		
SAB:the injury type classified by Lauge-Hansen classification.		

In addition to the routine preoperative X-ray and CT examination before surgery, MRI examination was undergone to clarify ligament injury in 19 patients and the ultrasound examination was adopted to further confirm whether the ligament was ruptured in all patients, except for 4 patients severely injured unable to tolerate MRI. In particularly, after the patients were anesthetized, the intraoperative fluoroscopic stress testing (Front drawer test, Varus stress test) was applied to prone to re-examine the stability of the ankle joint before surgery or after intraoperative fixation of the bone fracture. According to the intraoperative investigation, the diagnosis of ligament injury should be finally identified.

What is more, the study was approved by the ethics committee of our hospital(2019061), and all patients agreed and signed the informed consent.

2. Treatment

2.1 Preoperative Preparation

All patients received local cold compression and temporary plaster or brace fixation immediately after injury. The patient with talus dislocation in this study was successfully restored with emergency manual reduction. On most occasions, after the sufficient imaging examinations were processed to evaluate the fracture and ligament injury, operation was performed 5–7 days later for all patients.

2.2 Operative Treatment

The patients received lumbar epidural anesthesia or general anesthesia and placed in supine position with a thigh tourniquet. First, after the anesthesia was successfully performed, the fluoroscopic stress testing and ankle being passively flexed and extended were performed to further clarify the stability of the ankle.

Next, in the cases of calcaneus fracture, lateral malleolus fracture combined with subtalar joint dislocation, they were treated via tarsal sinus incision combined with medial sustentaculum tali approach to reduce and fix the fracture. During the operation, the ipsilateral CFL and ATFL were visualized and operatively treated through the tarsal sinus approach: After dissection of periarticular adipose tissue, the ligaments avulsed from the end were identified, and then fragments of osteophyte around the ankle, talus or calcaneus were removed, before ligaments were fixed with 3.5 mm anchors in situ.

In the 3 cases of talus fracture, the talus was restored via conventional anteromedial in combination with anterolateral incision, at the same time the talus was fixed with 2 ~ 3 4.0 mm hollow screws. By means of exploring ATFL and CFL from the anterior-external incision, suture and fixation of the end-ruptured ATFL could be completed at this incision. In addition, if the CFL was avulsed from the calcaneus, another approach about 1 cm should be made proximal to the calcaneus where CFL ends, to fix the CFL with anchor. After the ligaments were repaired, the ankle joint was fixed with a movable external fixator.

Patients with II degree of supination-abduction (SAB) classified by Lauge-Hansen classification were treated with reconstruction plate joint hollow screw or distal medial tibial locking plate. And then the lateral ankle incision was adopted to explore the lateral ligament. If the avulsion fracture of the lateral malleolus was greater than 5 mm, 2.7 mm hollow screw could be used to fix the fracture for the purpose of repairing the ruptured ligament; and if the fracture fragment was too small, remove it. In addition, the means of suture with anchor for avulsed ligament or fragment from talus or calcaneus were as same as mentioned. Moreover, one case of this type was an old ATFL injury combined with internal ankle fracture. Intraoperative exploration of ATFL indicated the contracture degeneration of ligament, leading to the impossibility of repair directly, in which the extensor retinaculum was transferred toward to anterolateral malleolus and sutured on the fibula.

The 10 cases of ankle sprain, who were combined with lateral ankle or talus avulsion fracture and accompanied by lateral ligament rupture, were treated in the same way as those of II degree of SAB ankle

fracture. One of them was a patient suffered from avulsion fracture of lateral malleolus and ATFL&CFL injury, whose ATFL ligament was torn from the middle. We fixed it to the ligament insertion of talus and fibula respectively with 4.5 mm screws by InternalBrace method. So that, the broken ends of ATFL were closer together, the tension was restored and the repair of lesion was promoted.

2.3 Postoperative treatment

All patients were fixed on neutral and slightly valgus position with a plaster support, and it was removed 6 weeks later. Patients were advised to return to normal activity 6 weeks postoperatively. Furthermore, for patients with avulsion fracture of lateral malleolus combined with ligament injury, ankle protection for 3 months while walking was recommended. For patients accompanied with fracture of other parts, they diverted to Airbrace, the progressive weight-bearing exercise. In the cases of talus fracture, the external fixation was adjusted to the movable state 6 weeks later after operation, while exercise of ankle joint without weight-bearing was encouraged. The external fixation was not pulled out until the talus fracture was basically healed.

2.4 The follow-up evaluation

X-ray was reviewed 6/12/24 weeks and 1/2 year after surgery. CT examination was performed when necessary. In order to obtain more accurate operative effect, Patients with talus fracture were followed up for 2.5 years. Especially the final follow-up was assessed by American orthopedic foot and ankle-society (AOFAS) score. The overall efficacy of the postoperative ankle joint was comprehensively assessed from pain (40 points), foot function (50 points) and bone alignment (10 points). 86 ~ 100 is excellent, 71 ~ 85 is good, 51□70 is acceptable and below 50 is poor.

3. Result

All the patients in this study were followed up for an average of 27.4 (range,25–29) months, and the healing time of fracture was 10.09 ± 3.61 (range, 6–24) weeks. Furthermore, Subtalar arthritis occurred in one case of calcaneus□lateral malleolus fracture combined with subtalar joint dislocation. So subtalar joint arthrodesis was performed 14 months after the initial operation. And during the follow-up period of talus fracture and dislocation, there was no talus necrosis occurring. Apart from this, two patients suffered from medial talus cartilage injury among the remaining cases,1 of which underwent microfracture surgery 1 year after surgery and another recovered from conservative treatment.

All in all, there was no chronic instability of ankle and subtalar joints during the follow-up. The final AOFAS score was (83.70 ± 4.69), including 19 cases were excellent and 4 cases were good. Typical cases are shown (Fig. 1, 2).

4. Discussion

4.1 The treatment of acute ankle ligament injury

Lateral ligament of the ankle joint mainly consist of three ligaments: ATFL, CFL and posterior talofibular ligament (PTFL). As we know, the PTFL injury is extremely rare. Therefore, the injury of the lateral ankle ligament is usually referred to as ATFL and/or CFL injury. According to Chorley's classification criteria, the injury of the lateral ligament complex of the ankle without fracture can be categorized into three degree: Grade I injury refers to the slight strain of ligament and the tear of ligament fiber, but the joint is stable; Grade II injury refers to partial ligament rupture, local swelling and pain, regional loss of ankle function with mild or moderate instability; Grade III injury refers to total ligament rupture, obvious local swelling and tenderness, subcutaneous ecchymosis, joint relaxation and instability[5]. In short, the I and II degree of injuries mainly indicate ligament contusion and partial tearing. Conservative treatment can live up to great clinical expectation, and the recovery of function after treatment is also satisfied. Whereas the III degree ankle joint injury implies the complete tear of ATFL and CFL, which can cause instability and functional decline of ankle joint. To make the matters worse, there is some controversy in its treatment.

By means of local injection of hyaluronic acid, strict ankle plaster fixation for 6 weeks and individualized rehabilitation treatment for 3weeks, Řezaninova *et al* treated 17 young athletes at III degree lateral ligament injury and followed them up for one year[6]. As a result, none of ankle instability occurred. In contrast, Suhr *et al* followed up 416 patients with ankle sprain who received conservative treatment, 15.9% (66 cases) requiring re-operation[3]. Kerkhoffs *et al* retrospectively analyzed the results of the conservative treatment and operative treatment for 2562 male adult patients with injury of lateral ankle ligament complex[7]. The result showed that the effective rate of emergency operative treatment was 90%~95%, which was superior to conservative treatment in terms of the activity of daily living, preventing chronic pain, recurrent sprains and the subjective or functional ankle instability. Contrary to research results above, the operative treatment in acute stage is not recommended for simple □ degree ankle ligament injury yet according to the current relevant guidelines[8].

At present, there is no relevant literature to report the incidence of ankle joint instability after fixing the fracture alone for patients with ankle fracture combined with lateral ligament injury. However, on the basis of the injury mechanism of lateral ligament of ankle joint: If the foot is suddenly on adduction or entropion when the ankle joint in the plantar-flexion position, strong tension on the lateral ligament of the ankle joint may lead to ligament strain, rupture even avulsion fracture. In consideration of the instability caused by the rupture of ankle ligaments, if the force is not removed right away, there will be collision between the bone and the bone, resulting in the fracture of ankle. Consequently, in this situation the force of injury is significantly greater than that of ankle ligament injury alone, the degree of injury is more serious and the range is more extensive. Once the patients, who have underwent ankle fracture caused by trauma, suffer from chronic instability of ankle joint after operation, the incidence of traumatic arthritis and chronic cartilage injury are more likely to be higher, and the time of complications occurring is earlier[9]. Therefore, we advocate the simultaneous repair of ligaments rupture and fracture fixation for patients who with ankle fracture complicated with III degree ankle ligament injury.

4.2 The diagnosis of Acute □ Degree Injury of Lateral Ankle Ligament complex

In this study, all the patients had fresh fracture combined with lateral ligament complex injury of ankle joint, so it was difficult to carry out drawer test, talus tilt test and stress position test for detecting ankle joint stability. And even if MRI was performed, it was often difficult to distinguish whether ligament was completely ruptured due to the factors such as bleeding and edema in the acute state. Opposed to MRI, by conducting Ultrasound for patients with acute ligament injury, not only could the edema and coarsening of ligament, abnormal signal in ligament (low signal, high signal, blood flow signal, etc.), ligament relaxation after rupture and avulsion fracture accompanying with Ligament insertion rupture, be obviously observed, but also Ultrasound has the advantages of dynamic observation and high specificity[10].As a consequence, it can be widely used in preoperative diagnosis of acute and chronic ankle injuries. So in recent years, more and more scholars have adopted Ultrasound for the diagnosis of ankle ligament injury[11]. For this study of cases, we presented Ultrasound as a routinely performed examination before surgery, the imaging results of which were basically consistent with those during operation.

Secondly, in order to further confirm the ligament injury and decide whether there is need to repair the lateral ligament, the stress position of the patients in this study was examined by intraoperative fluoroscopy after anesthesia or intraoperative fixation of the fracture. And for the reason that the anterior drawer test and talus tilt test differed greatly for individual, the stress image of ankle joint on the healthy side compared with that of the lesion side should be as the judgement standard[12]. If one of the following conditions occurred, it should be judged that the lateral instability of the ankle joint existed and the lateral ligament required repairing: Inclination of talus more than 10 degrees or anterior displacement of talus more than 8 mm under stress radio-graphs; Compared to the opposite side, inclination of talus more than 5 degrees or anterior displacement of talus more than 5 mm.

4.3 operative indications and advantages of one-stage repair of ankle fracture combined with lateral ligament injury

Due to the conservative treatment for degree of Lateral ankle ligament damage alone having a good effect on about 85% of patients[3], the operative indications should be strictly controlled for the one-stage repair of ankle fracture combined with lateral ligament injury. But there is absence of relevant literature for reference, the following operative indications are proposed:

Patients for Grade III injury of lateral ligament with foot and ankle fracture requiring operation.

If combined with intra-articular fracture of foot and ankle, the repair of the lateral ligament can provide a stable ankle joint, which is beneficial for reducing or delaying the incidence of postoperative traumatic arthritis[13]; If accompanied with internal ankle fracture, it is often caused by the collision of internal talus, which is easy to cause damage to talus cartilage. After the repair of lateral ligament, stable ankle joint is conducive to the self-repair of mild cartilage injury and the prevention of subsequent cartilage injury[14, 15]. If attached with fracture of talus and fibula, the repair of lateral ligament injury can be completed within the same approach, so the operative trauma is limited.

 Patients for degree injury of the lateral ligaments associated with Avulsion fracture

Reiner *et al* counted 47 patients with reconstruction of lateral ankle ligament, of whom 66% (31cases) had avulsion fracture of ankle joint or fibular[16]. Avulsion fracture indirectly indicates the degree of ligament injury, and the avulsion of ligament insertion also increases the length of ligament, raising the possibility of the instability of ankle joint. Moreover, if the free bone fragment can't be absorbed, it would be free in the joint, which may cause collision and damage to the articular cartilage, so the removal of free fragment and repair of the lateral ligaments can relieve pain and reduce the incidence of chronic instability.

 Ankle and foot fracture in patients who with chronic instability of the lateral ankle in the past

In this part of patients, operative indications are available for them before flesh fracture occurs, hence during the surgery after anesthesia, the fracture fixation and ligament repair could be performed at the same time, which reduces the risk of re-operation and the medical cost, and also helps to improve the activity of daily living after injury.

Patients for Simultaneous degree injury of ATFL and CFL

It was reported that the rotation of medial ankle joint increased 3 times after the ATFL rupture. What's more, the rotation will increase by 4 times if the ATFL and CFL are all broken. It is easy to cause damage to the medial triangle ligament and aggravate the instability of the ankle joint[17]. To avoid the chronic injury of the triangular ligament, the lateral ligament repair should be promoted[18].

4.4 approach of repair methods for lateral ankle ligament complex

In this study, a large proportion (22 cases in 23) were acute Lateral ankle ligaments injuries, and the damage position were all located at the tendon insertion point, leading to the fact that it could be directly repaired by anchor nails. For the purpose of effectively restoring the stability and preventing the complications of chronic instability of the ankle joint, Liu *et al* applied small incision for anchor to repair acute III degree injury of the Lateral ankle ligament and made it[19]. On the other hand, it is known that the cases of middle ligament rupture were rare among the injuries of lateral ligament (only 1 case was found in this study). Since the length of CFL is 20–30 mm and ATFL is 12–20 mm, both of them are too short to be sutured directly. InternalBrace method can be employed to make both ends of the ligament closer together to achieve the repair[20]. Meanwhile only 1 case suffered from old lateral ligament injury combined with supination-adduction injury, and was repaired by the improved Bröstrum-Gould method whose excellent rate was confirmed to be up to 94.7%[21].

5. Conclusions

Above all, this study is a retrospective series of case studies. it has several limitations, including a small number of patients, lack of comparison with other treatment modality and lack of longterm results.

However, from the current follow-up results of 23 patients, none of them presented chronic instability of the ankle joint. Therefore, it is supposed to try and promote the repair of the □ degree ligament damage while fixing the fracture, so as to obtain a larger sample and multi-center study results.

Abbreviations

ATFL anterior talofibular ligament

CFL calcaneofibular ligament

PTFL posterior talofibular ligament

AOFAS American orthopedic foot and ankle-society

Declarations

Acknowledgements

Not applicable.

Authors' contributions

YL, YGR conceived and designed the study. ZCQ, DLL recruited and followed up patients. Data collection and analysis were undertaken by ZC. All authors contributed to the manuscript and reviewed and approved the final submission.

Funding

The Project is sponsored by Cultivation Fund of Zhongnan Hospital of Wuhan University (2018303033); Natural Fund Project of Hubei Province (2016CFB455);

Availability of data and materials

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

Ethics approval and consent to participate

Data already from clinical routine were analyzed after approval by Medical Ethics Committee, Zhongnan Hospital of Wuhan University. Informed consent was obtained from all individual participants included in the study.

Consent for publication

All participants signed an informed consent form to participate in the study. The project information contained information about the intention to publish the work.

Competing interests

Not applicable.

Contributor Information

Chunquan Zhu E-mail: chunquan112@163.com

Linglong Deng E-mail: 893087265@qq.com

Chong Zhang , E-mail: 179886937@qq.com

Guorong Yu, E-mail: 1340715042@163.com

Li Yu, E-mail:yzorthopedics@whu.edu.cn

References

1. van den Bekerom MP, Kerkhoffs GM, McCollum GA, Calder JD, van Dijk CN. Management of acute lateral ankle ligament injury in the athlete. Knee Surg Sports Traumatol Arthrosc. 2013;21(6):1390–5. doi:10.1007/s00167-012-2252-7.
2. Hu Y, Tao H, Qiao Y, Ma K, Hua Y, Yan X, Chen S. Evaluation of the Talar Cartilage in Chronic Lateral Ankle Instability with Lateral Ligament Injury Using Biochemical T2* Mapping: Correlation with Clinical Symptoms. Acad Radiol. 2018;25(11):1415–21. doi:10.1016/j.acra.2018.01.021.
3. Suhr A, Muckley T, Hofmann GO, Spahn G. [Therapy of acute ankle sprain: one-year results of primary conservative treatment]. Sportverletz Sportschaden. 2012;26(1):39–44. doi:10.1055/s-0031-1299108.
4. Chaudhry H, Simunovic N, Petrisor B. Cochrane in CORR (R): surgical versus conservative treatment for acute injuries of the lateral ligament complex of the ankle in adults (review). Clin Orthop Relat Res. 2015;473(1):17–22. doi:10.1007/s11999-014-4018-7.
5. Chorley JN, Hergenroeder AC. Management of ankle sprains. Pediatr Ann. 1997;26(1):56–64. doi:10.3928/0090-4481-19970101-11.
6. Rezaninova J, Hrazdira L, Moc Kralova D, Svoboda Z, Benaroya A. Advanced conservative treatment of complete acute rupture of the lateral ankle ligaments: Verifying by stabilometry. Foot Ankle Surg. 2018;24(1):65–70. doi:10.1016/j.fas.2016.12.001.
7. Kerkhoffs GM, Handoll HH, de Bie R, Rowe BH, Struijs PA. (2007) Surgical versus conservative treatment for acute injuries of the lateral ligament complex of the ankle in adults. Cochrane Database Syst Rev (2):CD000380. doi:10.1002/14651858.CD000380.pub2.

8. Kerkhoffs GM, van den Bekerom M, Elders LA, van Beek PA, Hullegie WA, Bloemers GM, de Heus EM, Loogman MC, Rosenbrand KC, Kuipers T, Hoogstraten JW, Dekker R, Ten Duis HJ, van Dijk CN, van Tulder MW, van der Wees PJ, de Bie RA. Diagnosis, treatment and prevention of ankle sprains: an evidence-based clinical guideline. Br J Sports Med. 2012;46(12):854–60. doi:10.1136/bjsports-2011-090490.
9. Sugimoto K, Takakura Y, Okahashi K, Samoto N, Kawate K, Iwai M. Chondral injuries of the ankle with recurrent lateral instability: an arthroscopic study. J Bone Joint Surg Am. 2009;91(1):99–106. doi:10.2106/JBJS.G.00087.
10. Alves T, Dong Q, Jacobson J, Yablon C, Gandikota G. Normal and Injured Ankle Ligaments on Ultrasonography With Magnetic Resonance Imaging Correlation. J Ultrasound Med. 2019;38(2):513–28. doi:10.1002/jum.14716.
11. Doring S, Provyn S, Marcelis S, Shahabpour M, Boulet C, de Mey J, De Smet A, De Maeseneer M. Ankle and midfoot ligaments: Ultrasound with anatomical correlation: A review. Eur J Radiol. 2018;107:216–26. doi:10.1016/j.ejrad.2018.08.011.
12. Jolman S, Robbins J, Lewis L, Wilkes M, Ryan P. Comparison of Magnetic Resonance Imaging and Stress Radiographs in the Evaluation of Chronic Lateral Ankle Instability. Foot Ankle Int. 2017;38(4):397–404. doi:10.1177/1071100716685526.
13. Hirose K, Murakami G, Minowa T, Kura H, Yamashita T. Lateral ligament injury of the ankle and associated articular cartilage degeneration in the talocrural joint: anatomic study using elderly cadavers. J Orthop Sci. 2004;9(1):37–43. doi:10.1007/s00776-003-0732-9.
14. van Dijk CN, Reilingh ML, Zengerink M, van Bergen CJ. Osteochondral defects in the ankle: why painful? Knee Surg Sports Traumatol Arthrosc. 2010;18(5):570–80. doi:10.1007/s00167-010-1064-x.
15. Taga I, Shino K, Inoue M, Nakata K, Maeda A. Articular cartilage lesions in ankles with lateral ligament injury. An arthroscopic study. Am J Sports Med. 1993;21(1):120–6. doi:10.1177/036354659302100120. discussion 126–127.
16. Reiner MM, Sharpe JJ. The Role of the Accessory Malleolar Ossicles and Malleolar Avulsion Fractures in Lateral Ankle Ligament Reconstruction. Foot Ankle Spec. 2018;11(4):308–14. doi:10.1177/1938640017729498.
17. Guerra-Pinto F, Corte-Real N, Mota Gomes T, Silva MD, Consciencia JG, Monzo M, Oliva XM. Rotational Instability after Anterior Talofibular and Calcaneofibular Ligament Section: The Experimental Basis for the Ankle Pivot Test. J Foot Ankle Surg. 2018;57(6):1087–91. doi:10.1053/j.jfas.2018.03.038.
18. Yasuda T, Shima H, Mori K, Tsujinaka S, Neo M. Simultaneous Reconstruction of the Medial and Lateral Collateral Ligaments for Chronic Combined Ligament Injuries of the Ankle. Am J Sports Med. 2017;45(9):2052–60. doi:10.1177/0363546517700859.
19. Liu XF, Fang Y, Cao ZH, Li GF, Yang GQ. Repair of acute injuries of the lateral ligament complex of the ankle by suture anchors. Int J Clin Exp Med. 2015;8(11):21796–801.

20. Willegger M, Benca E, Hirtler L, Hradecky K, Holinka J, Windhager R, Schuh R. Biomechanical stability of tape augmentation for anterior talofibular ligament (ATFL) repair compared to the native ATFL. Knee Surg Sports Traumatol Arthrosc. 2016;24(4):1015–21. doi:10.1007/s00167-016-4048-7.
21. Nery C, Raduan F, Del Buono A, Asaumi ID, Cohen M, Maffulli N. Arthroscopic-assisted Brostrom-Gould for chronic ankle instability: a long-term follow-up. Am J Sports Med. 2011;39(11):2381–8. doi:10.1177/0363546511416069.

Figures

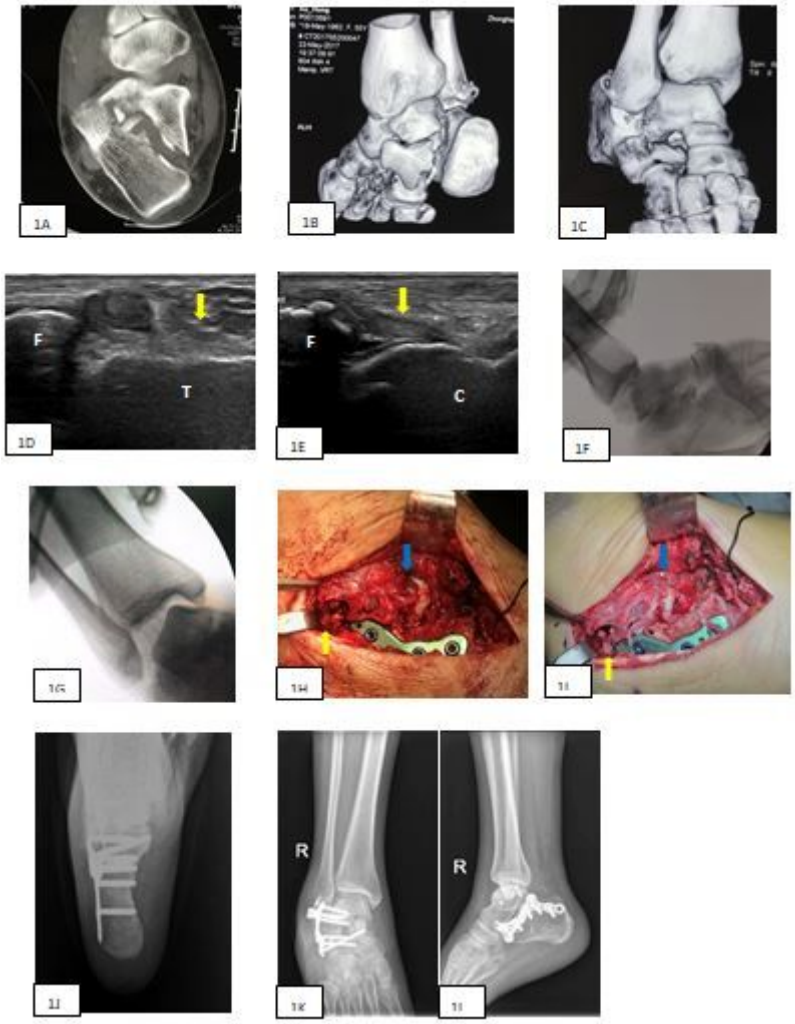

Figure 1

Female, 55 years old. Right calcaneus fracture, dislocation of subtalar joint, avulsion fracture of fibula and talus with III degree ATFL & CFL injury for traffic accident. (1A, 1B, 1C) Bone Fracture and Dislocation mentioned above. (1D) Hemorrhage (Hypoechoic area) in ATFL in preoperative Ultrasound; Arrow as ATFL;T as talus; F as fibula. (1E) CFL avulsion fracture from the fibula; Arrow as CFL; C as calcaneus. (1F, 1G) Anterior displacement about 18 mm and inclination about 25° for talus in intraoperative stress testing. (1H) Intraoperatively CFL rupture from fibula (yellow arrow) and ATFL rupture from talus (blue

arrow). (1I) ATFL and CFL were sewn with suture anchors respectively. (1J, 1K, 1L) Calcaneus fracture was healed basically and internal fixation and anchor were in good position three months later.

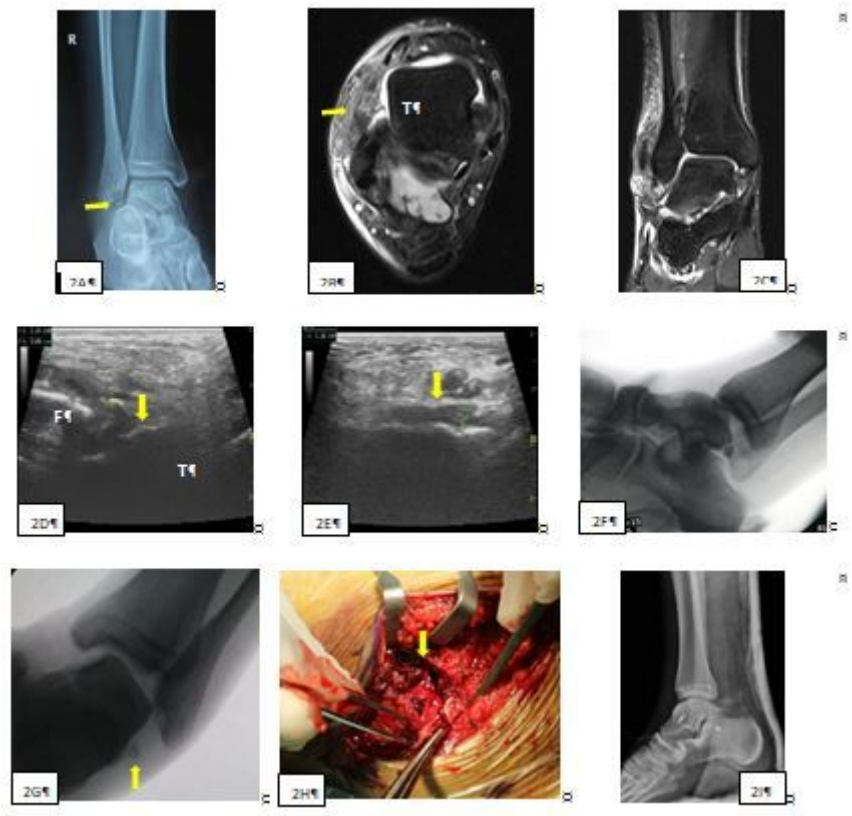

Figure 2

Male, 19 years old. Avulsion fracture of talus with III degree ATFL & CFL injury for sports injury. (2A) Preoperative X-ray showed avulsion fracture about 5mm between talus and fibula. (2B) Transverse section MRI showed the ATFL rupture. (2C) Coronal section MRI showed CFL rupture and tendon sheath hydrocele of fibula brevis. (2D) Preoperative Ultrasound identified fracture fragment as a 5 mm hyperechoic area between talus and fibula. (2E) No obvious CFL echo was observed; Only Banded liquid dark area was observed (arrow); CFL was thicker about 3.5mm in fibula side with poor tension. (2F, 2G) Anterior displacement about 12 mm and inclination about 20° for talus in intraoperative ankle stress testing; Visible fragment of avulsion fracture from talus (arrow). (2H) It showed CFL rupture from calcaneus and ATFL rupture from talus during the operation (arrow). After the fragment was cleared, the ligament was sutured and fixed with suture anchor. (2I) Postoperative X-ray showed the anchor was in good position.