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Review Article

Progress in the Treatment of Logsplitter Injury: An Illustrated Review

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ABSTRACT

Logsplitter injury is an ankle joint injury caused by high-energy axial violence with significant separation of inferior tibiofibular syndesmosis. Surgery is the mainstay treatment. The fracture should be treated in stages depending on the condition of the soft tissue. The integrity and smoothness of the ankle joint surface should be restored as much as possible during the surgery. This article discusses the treatment strategies of logsplitter injuries. Thorough research of the available literatures was done aiming to provide a standard treatment protocol. When combined with posterior malleolus fracture, anatomical reduction of posterior malleolus is necessary to reconstruct posterior tibial notch and then lateral malleolus. This reduction sequence is very important. Anatomical locking plates have been widely used in the fixation of fibular fractures. Anatomical reduction and fixation of the inferior tibiofibular syndesmosis is the key factor to achieve good functional results. There are still some controversies on how to accurately judge the stability of the inferior tibiofibular syndesmosis. Screws are the main method of fixing the inferior tibiofibular syndesmosis at present. Ankle arthroplasty or ankle arthrodesis may be necessary if the cartilage of the ankle joint is extensively damaged or if the ankle joint is severely comminuted. At present, the therapeutic and prognostic effects of these injuries are poor. The main influencing factors include the degree of injury, anatomical reduction of the fracture and dislocation, recovery of ankle stability and the reconstruction of ankle joint surface.

Key words: Anatomical Reduction, Fracture And Dislocation, Inferior Tibiofibular Syndesmosis, Logsplitter Injury.

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INTRODUCTION

Lower tibiofibular joint injuries are common in all kinds of ankle joint injuries. They often occur as potential or minor combined injuries in ankle joint injuries caused by low-energy rotation. For example, supination-external rotation and pronation-external rotation in Lauge-Hansen classification of ankle joint are often accompanied by lower tibiofibular joint injuries. More significant dislocation injury of the lower tibiofibular joint occurs in the fracture and dislocation of the ankle caused by high-energy axial violence.[1,2]

Logsplitter injury, first proposed by Hassan R in 2013, is a kind of fracture and dislocation of ankle joint caused by high-energy axial violence. The talus wedges into the lower tibiofibular joint, which results in significant syndesmotic disruption, often accompanied by the injury of the ankle joint surface and the ligaments around the ankle joint. Its damage mechanism is similar to that of wedge splitter, so it is also called "splitter" injury, or "ankle fracture and dislocation with significant separation injury of lower tibiofibular joint".[3]

When high-energy axial violence acts on the ankle joint in neutral or external rotation position, the ankle joint surface is injured first, which may include articular cartilage injury, articular surface collapse fracture and splitting fracture involving the articular surface; when the violence continues to conduct upward, it results in fibular fracture and lower tibiofibular joint injury, and finally wedging of the talus into the lower tibiofibular joint leads to significant separation injury of lower tibiofibular joint. Fracture dislocation is accompanied by injury of ligament around ankle joint, or avulsion fracture with ligament attachments.[1,2] Logsplitter injuries are mostly open injuries. The main characteristics of Logsplitter injuries are fracture and dislocation of ankle joint and significant separation injury of lower tibiofibular joint. In this case, the ankle becomes a "floating ankle"[4], which is extremely unstable. The injury can be diagnosed by clinical manifestations and routine X-ray examination. Three-dimensional CT scans can further elaborate the fracture and dislocation, which is helpful in guiding the treatment plan.

At present, there are some controversies and misconceptions regarding the treatment of Logsplitter injury and the prognosis is not satisfactory. This article aims to review the treatment of Logsplitter injury.

THERAPEUTIC PRINCIPLES AND STRATEGIES

AO believes that all unstable intra-articular fractures require open reduction to ensure anatomical reduction and anatomical reduction is directly related to therapeutic effect and prognosis.[5] The instability of the ankle joint and the corresponding stress changes will accelerate the injury and degeneration of the cartilage of the ankle joint surface, which is the pathological basis of long-term traumatic arthritis of the ankle joint.[6,7] Brodie et al.[8] considered that the absolute instability of ankle joint includes bimalleolar or trimalleolar fracture; lateral malleolus fracture with significant displacement of talus; fracture and dislocation of ankle joint.

Logsplitter injury is characterized by fracture and dislocation of ankle joint combined with significant separation injury of lower tibiofibular joint and extremely unstable ankle joint, which fully conforms to the above mentioned surgical indications, so surgery is the preferred treatment method.[1,2,9] The purpose of the surgery is to remove the soft tissue embedded between the fracture ends, restore the integrity and smoothness of the ankle joint surface, anatomical reduction of the ankle joint as much as possible, and restore the stability of the ankle joint, so that the patients can start functional exercises early, in order to obtain better functional recovery and prognosis.[10] The key point and difficulty in surgery is to restore the normal anatomical relationship of ankle joint and restore the stability of ankle joint.[9,10]

Age is not the decisive factor for surgery. Ankle reconstruction is equally important for young and old people.[11,12] It is necessary to debride and stabilize ankle joint in time even in elderly patients with cardiopulmonary disease, diabetes mellitus and peripheral vascular disease.[13]

Since the injury is an open and unstable ankle joint injury, when serious soft tissue injury or wound infection occurs, according to Tscherne-Gotzen soft tissue injury classification[14], staged treatment is needed to improve the condition of soft tissue and prevent infection. At the same time, the condition of the injury must be fully assessed and surgical plan designed to achieve good reduction and fixation. Tscherne et al.[15] suggested that one-stage debridement (especially in the articular cavity) should be performed thoroughly, talus should be reduced, fibula should be fixed in one stage if necessary, then the wound should be covered with VSD, and calcaneal traction or temporary external fixation across ankle joint should be performed depending on ankle joint stability to restore limb length and force line.[13]

After good soft tissue condition and infection control, usually 5-14 days later, ankle joint reduction and fixation is performed. Fixation methods[3,10] include external fixator fixation, internal fixation, ankle joint replacement and ankle joint fusion. Temporary trans-ankle joint fixation is a very practical over-fixation method.[13] It can maintain the position of ankle joint stably, facilitate debridement, expansion, dressing change and other operations. It is also conducive to the placement and fixation of internal fixators in later operation. On the other hand, this temporary external fixator can continue to be used for ankle instability after internal fixation, providing additional stability for ligament repair.[9,10]

REPAIR OF ANKLE JOINT SURFACE

In the mechanism of injury, violence often leads to high energy axial ankle joint cartilage injury, articular surface collapse and fractures involving the articular surface fracture.[1-3] Incomplete and coarse articular surface will accelerate the wear and degradation of articular cartilage, which is closely related to the occurrence of traumatic arthritis.[16] Therefore, restoring the integrity and smoothness of the ankle joint surface is very important for the treatment effect and prognosis.

Articular cartilage has very weak self-repair ability, and its treatment has always been a difficult problem in the medical field. At present, its treatment methods include autologous chondrocyte transplantation, autologous or allogenic cartilage transplantation and micro-fracture surgery, but there is no known method yet to completely cure cartilage injury. For small-scale cartilage injury[18], it is advocated that ankle joint should be fixed stably for more than 4 weeks after operation, or that micro-fracture surgery of articular surface should be performed to promote the formation of fibrocartilage, so as to repair articular surface. Cartilage transplantation can be tried for large cartilage defect.[17] If the cartilage of the ankle joint surface is severely damaged or the ankle joint is severely comminuted, it is very difficult to repair the joint surface and reconstruct the ankle joint, hence may be necessary to perform ankle replacement or ankle joint fusion.[10]

In cases of collapsed fracture of articular surface, Tol et al.[16] suggested prying the bone to reconstruct the articular surface, and perform bone grafting to support the collapsed articular surface. The reduction criteria of articular surface are: intra-articular space < 2 mm, step < 1 mm.[19]

Complicated posterior malleolus fracture: Vertical splitting is often the main cause of posterior malleolus fracture caused by vertical violence, which can involve both the tibial vault and posterior tibial notch[1,4,10], so its treatment is not limited to the reconstruction of tibial articular surface. Gardner et al.[20] found that the stability of the lower tibiofibular joint could be restored by 70% after good reduction and fixation of the posterior malleolus. Scheidt et al.[21,22] showed that only by reconstructing the posterior tibial notch first, the fibula can be accurately repositioned in the notch. Poor repositioning of the posterior tibial notch will directly lead to poor repositioning of the fibula. Therefore, when the separation injury of the lower tibiofibular joint is combined with the fracture of the posterior malleolus, anatomical reduction of the posterior malleolus is necessary to restore the distal tibial articular surface and the posterior tibial notch, and then restore the lateral malleolus. This reduction sequence is very important. Therefore, the anatomical reduction of the posterior malleolus can not only restore the complete weight-bearing area of the tibial joint surface, but also help to restore the reduction, fixation and stability of the lower tibiofibular joint. Harper et al.[23] proposed that when the posterior malleolus fracture involved more than 10% of the ankle joint surface and the fracture had displacement, or when the fracture involved more than 25% of the ankle joint surface without displacement, the fracture must be fixed with lag screw; when the fracture involved more than 25% of the ankle joint surface with displacement of the fracture and could not achieve satisfactory reduction or comminuted fracture of the posterior malleolus, the T-plate must be used.

TREATMENT OF FIBULAR FRACTURE

Many clinical studies[24,25] have shown that in the treatment of ankle fracture and dislocation involving fibular fracture, the anatomical reduction and fixation of fibula are the key factors affecting the prognosis. Poor reduction of fibula can cause abnormal gap between ankle points and changes in the biomechanics of the ankle joint. After functional exercise and weight-bearing activities, ankle pain and traumatic joints often occur. In order to avoid fibular shortening and displacement, one-stage temporary fixation is recommended for fibular fracture, and then a second-stage accurate reduction and firm internal fixation are recommended.

Thordarson et al.[25,26] suggested that when fibula shortened or moved out more than 2 mm or rotated more than 5 degrees, surgery should be performed, especially for shortening deformity. According to CLennan and Ungersma score[27], fibula reduction criteria can be divided into: good reduction: fibula without shortening deformity, posterior displacement less than 2 mm, medial space widening less than 1 mm; acceptable replacement: fibula shortening less than 2 mm, posterior displacement between 2-4 mm, medial space widening less than 1-3 mm; failure of reduction: fibula shortening greater than 2mm, the posterior displacement is greater than 2-4mm, medial space widening is greater than 3mm.

The common errors in fibula reduction are shortening, displacement and rotation. Whether fibula has shortening or displacement can be found by intraoperative imaging and corrected in time. However, there is still a lack of certain criteria for judging whether fibula has rotation and whether it matches the posterior tibial notch.

The fixation methods of fibula[24] include screw, Kirschner wire, neutral plate, antiglide plate and anatomical plate, which need to be selected according to the location, size and number of fracture fragments. Screws and Kirschner wires can be used for simple fibular tips fractures. Neutral plate and antiglide plate double-cortical fixation can make fibula obtain good stability, which has been widely used. However, it should be noted that the distal end of fibula has a 10-15 degree valgus angle, and the plate should be pre-bent during the operation to make the fibula align normally. The hook plate of distal fibula combined with two lower tibiofibular joint screw introduced by Panchbhavi et al.[28] can provide strong fixation for osteoporotic ankle fracture with unlimited joint movement.

Neutralization plate is not suitable for fibular tip fracture. Anatomical locking plate of distal fibula[24] can be used almost for all types of fibula fracture, especially comminuted unstable fracture of distal fibula, which has been widely accepted in the clinical practice in recent years.

Anatomical plate conforms to the anatomical and physiological characteristics of the ankle joint and can be used to assist fibula reduction during the operation. The distal end of the plate has a porous design, which can avoid screw penetration into the articular cavity. The plate and screw lock each other to form a stable internal fixation system.

REDUCTION AND FIXATION OF LOWER TIBIOFIBULAR JOINT

After the separation injury of the lower tibiofibular joint, the talus moves outward, which leads to the reduction of the contact area of the tibiotalar joint and the abnormal distribution of the stress in the ankle joint.[1-4] Leeds et al.[29,30] found that if the gap between the medial fibula wall and the lateral tibial posterior malleolus wall on the posterior-anterior film of the ankle was more than 2 mm compared with the normal side, the incidence of long-term arthritis would be significantly increased. It was considered that the anatomical reduction of the lower tibiofibular joint was closely related to the therapeutic effect and functional prognosis. Dattani et al.[31] showed that 16% to 52% of the patients with lower tibiofibular joint had poor reduction if only closed reduction was performed, while the patients with surgical anatomical reduction and fixation had better prognosis. The purpose of tibiofibular joint fixation[1-4] is to create a stable environment for the healing of soft tissues such as ligaments.

Amendola[32] reported the anatomical relationship of the normal inferior tibiofibular syndesmosis on X-ray: 1) the tibiofibular space between the upper and lower tibia on anterior and posterior or ankle acupoint X-ray films was less than 6 mm; 2) the tibiofibular overlap on anterior and posterior X-ray films was more than 6 mm or 42% of the fibular width; 3) the tibiofibular overlap on ankle acupoint X-ray films was more than 1 mm. This can be used as a reference standard for reduction of tibiofibular joint.

Ebrabeim[33] considered that the absolute indication of the fixation of the inferior tibiofibular syndesmosis was the instability of the inferior tibiofibular joint after the fixation of the lateral and medial malleolus. However, there are still some difficulties and controversies on how to accurately judge the stability of the lower tibiofibular joint during the operation. Static data such as ankle gap measurement, tibiofibular overlap image measurement and angle measurement on X-ray film, dynamic physical tests such as Cotton test and extrusion test can be used to evaluate the stability of the lower tibiofibular joint.[34-39] However, Leeds et al.[29] found that even if the intraoperative imaging and physical examination were normal, the instability of the lower tibiofibular joint could not be completely ruled out. Porter et al.[40] reported that the "hook" test (i.e. gripping the fibula with a hook or forceps and pulling it outward) could improve the diagnostic rate of instability of the lower tibiofibular joint: if the distal fibula can be pulled outward for more than 3-4 mm, it is considered that the lower tibiofibular joint is unstable. However, the axial, transverse slip and rotation of fibula and lower tibiofibular joints are not consistent, and the certainty and validity of this test need to be further studied. Stress X-ray is a very valuable examination in ankle imaging. Jenkinson et al.[41] studied 38 cases of unstable external rotation ankle fracture. It was found that stress X-ray significantly improved the diagnostic rate of instability of lower tibiofibular joint. However, it is still difficult to use orthostatic X-ray in surgery.

The repair and fixation methods of lower tibiofibular joint[33,42] include: lower tibiofibular joint screw, Kirschner's needle, direct suture repair, tension band system, tendon fixation of long peroneal tendon, lower tibiofibular hook, U-type nail, rivet fixation system, suture button fixation system, microporous plate, bio-absorbable screw and so on, among which lower tibiofibular joint screw is the most widely used. Many studies[42-44] showed that there was no significant difference in the fixation effects of one or two screw, 3.5mm or 4.5mm diameter screw, screw through three or four layers of cortex, and the views on the position of the screw, the angle of the screw and the position of the ankle joint were basically the same. At present, the widely adopted method of screw fixation is: under the condition of ankle dorsiflexion 5 degrees, 2 cm above the tibial talus articular surface, parallel to the tibial talus articular surface, 25-30 degrees from the posterolateral to the anterolateral direction, perpendicular to the lower tibiofibular articular surface, a cortical bone screw with a diameter of 3.5mm or 4.5mm is inserted through three layers of cortex. Ankle joint is fixed for 4-6 weeks after operation to heal ligament scar, no or less weight-bearing functional exercise (mainly exercises for ankle mobility) before 8 weeks, lower tibiofibular screw is removed in time, 8-12 weeks after operation, and gradually, the ankle joint axial load-bearing strengthened. Normal weight-bearing walking started 12 weeks after fracture healing.

Weening et al.[45] pointed out that the fixation of lower tibiofibular joint screw made patients achieve better ankle function recovery, but whether the lower tibiofibular joint is anatomically reduced or not is closely related to the therapeutic effect. Kennedy et al.[46] found that poor reduction of the lower tibiofibular joint could lead to abnormal biomechanics of the ankle, leading to a significant increase in the incidence of post-operative ankle pain and long-term arthritis. However, it is not clear whether the fixation of the lower tibiofibular joint screw can produce the best functional results of the ankle joint, because in normal ankle movements, the lower tibiofibular joint has axial, transverse sliding and rotational motion.[47] It is not clear whether the loss of stability of the lower tibiofibular joint affects the stability, biomechanics and functional activities of the ankle joint.

Song et al.[44] reported that after follow-up of CT scan, it was found that the rate of poor reduction of tibiofibular joint after screw fixation was 36%. After removal of the lower tibiofibular screw, 89% of the lower tibiofibular joints could be self-repositioned. It is recommended that three-dimensional CT of ankle joint be reviewed regularly after operation. If the inferior tibiofibular joint is not completely matched, after excluding poor reduction of tibia and fibula, and when the ligament scar heals, consider removing the lower tibiofibular joint screw and gradually strengthening functional exercise.

In recent years, bio absorbable screw[33] has been widely used in trauma surgery. Its advantage is that the screw will be absorbed automatically by human body after fixed for a certain period of time, which can avoid reoperation, but its exact effect needs further study.

ANKLE ARTHRODESIS OR ANKLE REPLACEMENT

Ankle arthroplasty or ankle arthrodesis is generally not recommended as the main treatment for ankle fracture and dislocation. If the cartilage of the ankle joint surface is severely damaged or the ankle joint is severely comminuted, it is very difficult to repair the joint surface and reconstruct the ankle joint. In this condition, it may be necessary to perform ankle replacement or ankle joint fusion.[3,10]

In addition, poor reduction and instability of the ankle often lead to ankle pain, limited joint movement and traumatic arthritis. It may be difficult to avoid ankle replacement or ankle fusion in the later stage.

CURRENT STATUS OF TREATMENT

Hassan.R. et al.[1] A prospective study of 23 cases showed that the AOFAS score after Logsplitter injury was 67+/-26.8. Nearly half of the patients had tibial perifornix fractures, and were prone to wound infection (17%) and nonunion (17%). Although 21 of the 23 patients (87%) had achieved near-anatomical reconstruction, 16 of the 23 patients (70%) had imaging findings of arthritis at the final follow-up, and there was a great possibility of future surgical intervention.

At present, there are no long-term follow-up studies and the prognosis is uncertain. Hassan. R. and Tang Xin, a Chinese scholar[1-3], considered that the major factors influencing the therapeutic effect and prognosis were the degree of injury, anatomical reduction, recovery of ankle stability and reconstruction of ankle joint surface.

CONCLUSION

Most of the above clinical experience is based on retrospective research, and part of the content comes from the classical theory of ankle fracture and dislocation. Log splitter's injuries are complex and serious, and it is difficult to treat them. Better therapeutic effects need to be further studied in the fields of biology, biomechanics and clinical practice, such as the repair of articular cartilage, how to rotate fibula, how to accurately evaluate the stability of ankle joint during operation, the relationship between the activity of inferior tibiofibular joint and the stability of ankle joint, and the technique of orthostatic radiography during operation.

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