Title page

Localizer-assisted Arthroscopic Anterior Talofibular Ligament and Calcaneus Fibula Ligament Reconstruction for the Treatment of Chronic Lateral Ankle Instability

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Background Anatomic reconstruction has become one of the standard techniques used for the treatment of chronic ankle instability. Although arthroscopic treatment of chronic ankle instability has made remarkable progress in recent years, no comprehensive description of arthroscopic reconstruction of the ankle ligament is available. The purpose of this study is to describe the surgical technique of localizer-assisted arthroscopic anatomical reconstruction of the anterior talofibular ligament and the calcaneus fibular ligament and to evaluate the clinical effect in patients.

Method In total, 36 young adults with simple lateral ankle instability were treated with arthroscopic anatomical reconstruction of the anterior talofibular ligament and the calcaneus fibula ligament, including 20 males and 16 females with an average age of 27 years (17-35 years). All patients had more than three ankle sprains in the past two years. Physical examination revealed positive anterior drawer test results of the ankle and/or talus tilt test results. The operation was performed in two steps. First, we found the adjacent area center of the peroneal lateral stop of the talofibular ligament and the calcaneus fibular ligament on the surface of distal fibula, and the skin mark was made. The localizer guided the surgeon to the location, and then the fibula bone canal was created. Next, the residual end of the talofibular side stop of the anterior fibula ligament was located under the arthroscope, and the talofibular end bone canal was made after the localizer was accurately positioned. Then, the calcaneus lateral stop of calcaneus fibula ligament was located on the calcaneus body surface, and the skin mark was made. Furthermore, the calcaneus end bone canal was generated under guidance of the localizer. Finally, anatomical reconstruction of the anterior talofibular ligament and/or calcaneus fibula ligament was completed in a step-by-step manner. The clinical characteristics, preoperative and postoperative the American Orthopaedic Foot and Ankle Society (AOFAS) and Karlsson scores were recorded.

Results The AOFAS score increased from 60 (45-70) to 92 (80-98), and the Karlsson score increased from 62 (40-72) to 95 (75-96) after the operation. During the follow-up period, no patients experienced postoperative complications, such as infection at the incision, nerve injury, skin necrosis and ankle stiffness. No cases of recurrence of ankle instability were found.

Conclusion Arthroscopic reconstruction of the talofibular and calcaneus fibular ligaments can achieve satisfactory clinical results in the treatment of chronic ankle instability with lower recurrence rates and reduced complications compared with open surgery. Meanwhile, localizer-assisted reconstruction is a reliable and simple operation technology with high clinical success rates. In addition, increased understanding of anatomic markers is very important to avoid operation failure.

Keywords arthroscopy; ankle instability; reconstruction; surgical treatment

Ankle sprain is one of the most common sports injuries, accounting for approximately 14 - 30% of total body injuries, and ankle lateral ligament injuries account for approximately 90% of these injuries. Most patients with acute sprains recover the normal ankle function after strict conservative treatment, but 20 - 40% of the patients develop chronic ankle instability (CAI) [1-3]. Clinical manifestations include repeated sprain of the ankle joint and conscious relaxation and pain of the ankle joint during normal activities, which may eventually lead to ankle osteoarthritis [4,5]. At present, repair methods of ankle lateral structure injury mainly include repair, non-anatomical reconstruction and anatomical reconstruction. Relevant research shows that the effect of anatomical reconstruction is better than that of non-anatomical reconstruction and repair [6-8]. In recent years, arthroscopic anatomical reconstruction has become a new trend of surgical treatment [9-11] However, due to the relative narrow space of the ankle joint, the difficulty of exposing the fibula stop of the lateral ligament complex, and the irregular shape of talus and other related anatomical factors, anatomical reconstruction of the lateral ligament of the ankle joint under arthroscopy is associated with numerous problems, such as difficult exposure during the operation, easy injury of the lateral dermis and inaccurate ligament reconstruction point location. The purpose of this study was to describe the accurate positioning of the localizer of the anterior talofibular ligament and/or calcaneus fibula ligament with arthroscopic assistance and to evaluate the functional recovery of the ankle joint after operation.

Data and methods

1. General information

This study was a retrospective case series and was conducted in accordance with relevant guidelines and regulations.All subjects signed the informed consent form, If the subjects were under 18 years old, their parents signed the informed consent form.This study was approved by the institutional ethics committee of the First Affiliated Hospital of Guangxi Medical University.After receiving institutional ethics committee approval,we analysed the clinical effect CAI patients were treated with arthroscopic anatomical reconstruction of the anterior talofibular ligament and the calcaneus fibula ligament between February 2017 and December 2019.This study assessed 36 patients, including 20 males and 16 females with 21 left and 15 right ankle injuries with an average age of 27 (17-35) years. The average injury time was 16 months (8-24 months). The causes of injury were classified as follows: 25 cases of sports injuries, 10 cases of daily activities sprains, and 1 case of car accident injury. Physical examination revealed that patients suffered from lateral malleolus tenderness, more pain under inversion, positive front drawer test results, and positive talus tilt test results. All patients underwent preoperative X-ray examination of the C-arm in stress position under anesthesia (Figs. 1-2). The results showed that the talus moved forward more than 10 mm, and the talus tilt angle was less than 10 ° in 20 patients who underwent anterior fibular ligament reconstruction. Sixteen patients who exhibited talus forward movement greater than 10 mm and a talus tilt angle of greater than 10 ° underwent simultaneous reconstruction of the anterior fibular ligament and calcaneus fibula ligament.

with diffficulties in the accomplishment of MBP after ossicle resection . All patients underwent the ALR procedure as an alternative procedure. The study group comprised 11 males and 5 females. The average age at the time of surgery was 28.9 years (range, 16-65 years). The average fifinal follow-up time was 26.9 (range, 12-47) months.

Fig.1.Anteroposterior X-ray of the ankle joint under stress.

Fig.2.Lateral X-ray of the ankle joint under stress.

2. Inclusion and exclusion criteria

Inclusion criteria: (1) history of repeated varus ankle sprain; (2) patients who were treated conservatively for more than 6 months without obvious improvement in symptoms; (3) physical examination included positive front drawer test and/or varus stress test results; (4) patients whose talus moved forward and/or tilted in the anterolateral position of ankle joint as assessed by X-ray.

Exclusion criteria: (1) acute sprain of lateral ankle; (2) previous ankle fracture history; (3) ankle cartilage injury and traumatic arthritis; (4) foot limb deformity and neuromuscular disease of affected limb.

3. Operation method

The first step is to mark the skin marker of the bone, vein and tendon of ankle joint and to explore ankle joint under arthroscope.

We mark the projection area of the tip of the medial and lateral malleolus, the longitudinal axis of fibula, the great saphenous vein and the tendon surface with a sterile scriber. Then, we mark the location 8 mm from the front of the tip of the lateral malleolus. Then, the projection area of the surface of the labeled peroneal canal is the intersection of the straight line passing through the marked point and the longitudinal axis of the fibula by 30°, which is the common footprint of anterior talofibular ligament and calcaneus fibula ligament. Next, we evaluate the position of reconstruction point of fibular end ligament and measure the length of the bone canal on the body surface (Fig. 3).

To avoid the projection area of the great saphenous vein, we draw a vertical horizontal line between the tip of the medial malleolus and the longitudinal axis of the tibia. The location 5-10 mm from the horizontal line to the anterior part of the medial malleolus serves as the mark point for retrograde localization of the talus bone canal from the anterior fibular ligament (Fig. 4). Then, we draw a 45 ° straight line with the longitudinal axis of fibula through the tip of lateral malleolus, and a point on the calcaneus side approximately 10 mm from the lateral malleolus is marked as the reconstruction point of calcaneus fibula ligament (Fig. 3).

Fig.3.Location mark on the lateral surface of the ankle joint. Fig.4.Location mark of the medial surface of ankle joint.

We establish anterolateral and anteromedial approaches to the ankle, clear the hyperplastic synovium and osteophyte, and explore the stop and tension of anterior talofibular ligament and calcaneus fibula ligament. We make a skin incision approximately 2.0 cm long at approximately 2.0 cm medial to the ipsilateral tibial tubercle, cutting the gracilis tendon, which is measured as the diameter and length of the tendon, and reserve the 14 cm length of the graft. Then, both ends of the tendon are woven with high-strength suture, which is tensioned with 20 pounds tension for 10 min for standby.

The second step involves the use of the point-to-point anterior cruciate ligament (ACL) reconstruction tibial positioning system tool (Smith & nephew company) to prepare the bone canal under the guidance of localizer assistance(Fig. 5).

We place the two ends of the guide localizer at the marked points on the surface of the fibular bone canal and prepare the bone canal with a hollow drill with a diameter of 4.5 mm. Then, we measure the length of the bone canal and expand the bone canal with a matching reaming drill to complete the preparation of the bone canal and confirm the fibular end bone canal under an arthroscope (Figs. 6-8).

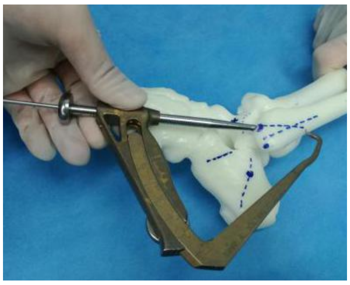


Fig.5.Anterior cruciate ligament reconstruction localizer. Fig. 6.Drilling the fibular canal with positioner on the model

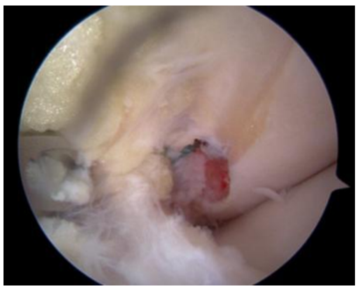
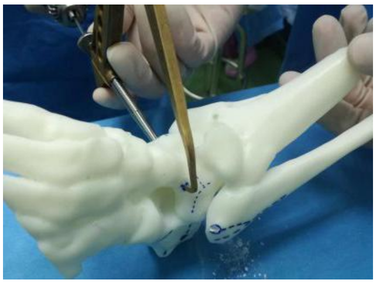


Fig.7.Drilling the fibular canal with the positioner. Fig.8.Confirming the fibular bone canal.

We clean the lateral recess of the ankle joint, separate the joint capsule and expose the anterolateral bone surface of talus neck. Then, we mark the intersection of 5 mm in front of the lateral cartilaginous surface of the talus and 10 mm below the talus neck, which serves as the footprint at the talus stop of the anterior talofibular ligament. This location is marked with the plasma electric knife. Then, we put the two ends of the point-to-point bone canal positioner at the marked points on the internal and external sides of the talus bone canal and drill a 2.0-mm diameter Kirschner wire from the internal malleolus. Then, we prepare the bone canal with a 4.5-mm diameter hollow drill and measure the length of the bone canal. Next, we enlarge the bone canal with a matching reaming drill to prepare the bone canal with a length of 2 cm and complete the preparation of the bone canal (Figs. 9-12).



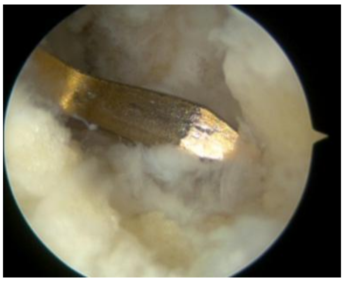
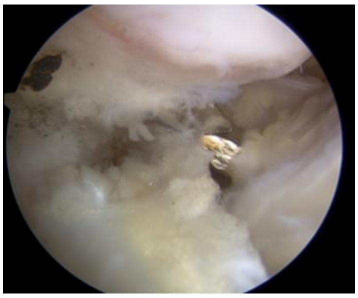


Fig.9.Drilling the talus bone canal with positioner on the model Fig.10.Guiding and locating the talus stop of the anterior fibular ligament.



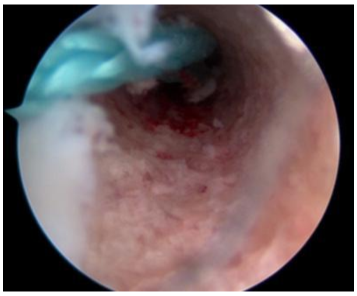


Fig.11.Drilling the talus bone canal with the positioner. Fig.12.Observation of the bone canal of talus.

We cut a skin incision approximately 1 cm long at the surface mark of calcaneus insertion point of calcaneus fibula ligament, separate tissue to the surface of calcaneus, localize the internal exit of calcaneus with the localizer, and avoid the medial malleolus. The calcaneal bone canal is created in the same manner.

We use a suspended fixation button plate to fix tendon reflexes of the double strand transplantation with a suspended fixation button plate and pull it into the fibular bone canal. Then, we pull the talus end of the graft into the talus canal. The calcaneus end penetrates from the long and short peroneal tendons to the calcaneus skin incision, and it is pulled into the calcaneal canal. In addition, 0 ° flexion and dorsiflexion of the ankle joint is maintained. Two 6.0 mm × 20 mm absorbable interface screws are used for extrusion fixation, and the ankle joint maintains plantar flexion and dorsiflexion at 0 ° and valgus flexion at 5-10 ° (Figs. 13 and 14).

Fig.13.Suture of the gracilis tendon.

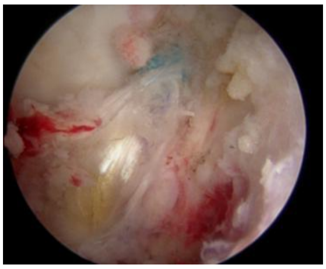


Fig.14.Observation of the anterior talofibular ligament after reconstruction.

4. Postoperative treatment

The ankle joint plaster of the affected limb was fixed in a neutral and slight eversion position. The affected limb was raised, and ice was applied. Lower limb muscle and knee joint functional exercises were gradually performed. Then, the ankle joint walking brace was replaced 2 weeks after the operation. Ankle joint functional exercises were started 4 weeks after the operation, and weight-bearing walking was performed 6 weeks after the operation. The ankle joint brace was removed 3 months after the operation.

5. Statistical analysis

The Karlsson score and the American Orthopaedic Foot and Ankle Society (AOFAS) ankle and hind foot scores were analyzed using SPSS 17.0 statistical software (SPSS Inc., Chicago, IL,USA) . The comparison of each index was made by paired t-tests, and results are expressed as ($x \pm s$). $P < 0.05$ indicates statistically significant differences.

Results

X-ray fluoroscopy of the C-arm and arthroscopic exploration under anesthesia stress were performed before the operation. This study included 20 patients (20 ankle joints) diagnosed with rupture of the anterior talofibular ligament who underwent intraoperatively guided arthroscopic reconstruction of the anterior fibular ligament and 16 patients (16 ankle joints) diagnosed with rupture of the anterior talofibular ligament and calcaneus fibula ligament who underwent intraoperatively guided arthroscopic reconstruction of the anterior talofibular ligament and calcaneus fibula ligament. No patient loss occurred during follow-up. All patients had an average follow-up of 26 months (12-32 months). The average AOFAS score was 60 ± 5.42 (45-70) before operation and 92 ± 3.78 (80-98) one year after operation. The difference was statistically significant before and after operation. The average Karlsson score was 62 ± 6.47 (40-72) before operation and 95 ± 3.54 (75-96) one year after operation.The difference was statistically significant before and after operation (Table 1). During the follow-up, ankle pain gradually disappeared. No postoperative complications, such as infection of the operation mouth, anklebone stiffness, and toe pain and numbness, were noted. At the last follow-up, the anterior drawer test and talus tilt test results were all negative.

Table.1 AOFAS and Karlsson Scores at One Year of Follow-up（n=36）

	Preoperative	Postoperative	t	P value
AOFAS score	60±5.42	92±3.78	37.167	0.001^{*}
Karlsson score	62±6.47	95±3.54	25.228	0.001^{*}

*：P<0.05.

Discussion

The ankle joint is one of the largest load-bearing joints when human body stands and walks. The lateral ankle ligament complex consists of the anterior talofibular ligament, the posterior talofibular ligament and the calcaneus fibula ligament, and the anterior talofibular ligament and calcaneus fibula ligament are important structures that maintain ankle stability. Anterior talofibular ligament and calcaneus fibular ligament injuries are easily caused by metatarsal flexion sprains [12]. Clinically, pain symptoms that are not relieved after 3 to 6 months of conservative treatment are diagnosed as chronic ankle instability (CAI) [4,5,9]. At present, the improved Broström technique is still regarded as the gold standard for the treatment of lateral ankle instability [5,7]. However, the number of patients undergoing arthroscopic ankle surgery is increasing rapidly. At present, this technique has gradually become a new trend of clinical CAI treatment [13-15].

CAI operation methods are mainly divided into suture repair and ligament reconstruction, and the Broström technique and its modified operations represent the primary methods of suture repair. However, when the patient's lateral ankle ligament tissue is relatively weak and missing, suture repair cannot provide sufficient stability. Over time, there is a tendency for ankle joint relapse [16-18]. Postoperative complications, such as injury of the superficial peroneal nerve and abnormal protrusion of the lateral soft tissue, are easily occur in anchor screw sutures [17,19]. However, the short-term and medium-term follow-up results of the anatomical reconstruction of the lateral ligament of the ankle are more accurate for young and middle-aged patients who are overweight and have high requirements for ankle joint motor function, patients for whom the quality of the residual end of the lateral ligament of ankle joint is poor or absent after repeated sprain, or patients who have failed to be sutured and are ready for revision [13,20].

The autogenous hamstring tendon is a mature and reliable technique in the reconstruction of knee ligament. The technique is also suitable for the reconstruction of the lateral ligament of ankle in clinic. The main method involves side to side stitching that was performed by cutting the back end of the double strand of the gracilis muscle. The other end was made of an elliptical cylinder by cross knitting and sewing. The aim of the procedure is to simulate the anatomy of the anterior talofibular ligament and the calcaneus fibula ligament, respectively [21,22].

Although the length and width of the anterior talofibular ligament and the calcaneus fibula ligament vary greatly with the changes of bone structure, autopsy studies have found that the mechanical center is relatively constant. The anterior talofibular ligament and calcaneus fibula ligament are very close to each other at the lateral insertion of fibula, which provides the anatomic basis for the reconstruction of the common bone canal of the anterior talofibular ligament and calcaneus fibula ligament [23,24]. Buerer et al. [16] found that the insertion points of the anterior talofibular ligament and calcaneus fibula ligament were located 8.1 mm and 10.1 mm from the distal fibula, respectively, and partial overlap is noted between the points. In addition, the high rate of common tendons at the insertion point and the limited thickness and diameter of the distal fibula are important features to consider in anatomical reconstruction of the anterior talofibular ligament and the calcaneus fibula ligament, multiple bone channels or the use of squeeze screws may lead to bone loss and bone cleavage [25,26]. In this group of cases, a single bone channel button plate was designed to suspend and fix the fibula side, which not only simulates anatomical reconstruction to the greatest extent but also avoids postoperative complications, such as distal fibular fracture. Compression fixation of the talus and calcaneus was achieved with absorbable interface screws, and the follow-up results were satisfactory. However, the distal fibula exhibits different morphology and tendon insertion, and numerous methods are available to create and fix the fibular bone canal. Thus, many controversies still exist in clinical reports [12,17,21,23-26].

Multiple old injuries are noted in patients with chronic lateral instability of the ankle, and its adjacent articular capsule and supporting zone exhibit different degrees of scarring. No obvious bony protuberances or tuberosity are noted in the anterior talofibular ligament and calcaneus fibula ligament at the lateral insertion of fibula [24,26], thus, it is relatively difficult to expose and locate this point during the operation. The skin of the distal fibula is relatively thin, and the bony mark is prominent. Its tip can be used as a bone reference mark during the operation. The parallel body surface location can be determined by measuring reconstruction points [16,27]. We think the particularity of its anatomy provides the possibility of drilling a fibular bone canal under the guidance of percutaneous localizer. Thus, in this study, we designed the surface positioning and guide device to drill the bone canal through skin point-to-point positioning. It is a practical technology worth popularizing.

The talus itself is an irregular bone. The lateral insertion of the talus of the anterior talofibular ligament is mostly located in the "bare area of cartilage" outside the talus neck or the deltoid area of tarsal canal. The migration inclination of the lateral articular surface of talus and the tarsal sinus area of talus neck is significant [28]. The location of the Kirschner wire easily slides during the operation. Moreover, after ankle joint swelling, the orientation of bone canal is easily altered. Many unfavorable factors cause confusion in intraoperative localization, so we designed a percutaneous retrograde localizer to guide and locate the talus bone canal to avoid the above problems. During the follow-up period, this group of patients achieved satisfactory clinical effects. Both Karlsson and AOFAS scores were significantly improved. Reoperation was not required for symptom recurrence. All patients could resume exercises performed prior to injury when they underwent active functional rehabilitation for 6 months after the operation. Our treatment outcome is consistent with similar clinical reports [6,25].

Conclusion

In summary, due to the small space of the lateral compartment of the ankle joint and complicated lateral structure, arthroscopic exposure is difficult. Clear vision is necessary, and neurovascular injury must be avoided. To maintain the blood supply around the talus, we need to balance the advantages and disadvantages of the operation. However, our research still has some limitations, including the small number of patients, short follow-up time and significant differences in ankle bone structure. Thus, it is necessary to further study currently available operation methods.

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(No:KY-E-134).

Author contributions

Liangjun Zhao collected and analyzed data and wrote the manuscript. Fang Xu, Shan Lao, and Jinmin Zhao analyzed data.Qingjun Wei helped to draft the manuscript. All authors reviewed the final manuscript. All authors agree to be accountable for all aspects of the work.

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Availability of data and material

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

Conflict of interest

The authors declare that they have no competing interests.

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