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Reconstruction of the lateral ankle ligaments using the anterior half of peroneus longus tendon graft

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ABSTRACT

Background: This study aimed to report our institution's experience in the treatment of chronic lateral ankle instability using the anterior half of the peroneus longus tendon (AHPLT) to reconstruct the lateral ligament.
Methods: This retrospective study included 32 consecutive patients with chronic lateral ankle instability who underwent surgery from January 2013 to December 2014. All patients had failed to resolve with conservative treatment. A total of 32 ankles underwent AHPLT transfer. Patients returned for a clinical and radiologic follow-up evaluation at an average of 28 (range, 24–35) months postoperatively. Outcomes were assessed by comparison of pre- and postoperative American Orthopaedic Foot and Ankle Society (AOFAS) scores, visual analog scale pain scores, and Karlsson scores, and the radiographic assessment including talar tilt and anterior talar translation.
Results: Thirty-two patients (32 ankles) (100%) returned for final evaluation. All patients had an excellent or good outcome on patient subjective self-assessment, pain scores, AOFAS scores, and Karlsson scores at final follow-up. Ankle range of motion was not affected by lateral ankle reconstruction. The talar tilt was significantly reduced from a preoperative mean of 14.1 ± 4.2° to 3.4 ± 1.3° postoperatively ($P < .001$), and the anterior drawer was significantly reduced from a preoperative mean of 13.8 ± 3.4 mm to 3.6 ± 1.5 mm after lateral ankle ligamentous reconstruction ($P < .001$).
Conclusions: AHPLT transfer to reconstruct the lateral ligament resulted in a high percentage of successful results, with excellent ankle stability and not affected of ankle motion.
Level of evidence: Level III-retrospective comparative study.

1. Introduction

Ankle sprains are the most common musculoskeletal injuries, especially in the active population, accounting for up to 20% of all sports-related injuries [1]. Ankle sprain results in ankle joint swelling and pain; depending on the initial treatment strategy and the number of ligaments involved, up to 40% of patients with lateral ligament injury eventually develop chronic lateral ankle instability (CLAI), which seriously affects quality of life [2].

CLAI can be treated by numerous effective methods, with an overall success rate for correction of instability of greater than 80% [3]. CLAI treatment methods include conservative treatment and surgical treatment. Initial conservative treatment involves physiotherapy and bracing, while continued problems may require surgical intervention. Surgical treatment includes the Broström–Gould procedure, or autograft and allograft tendon reconstruction.

The Broström–Gould procedure is widely used for the surgical treatment of chronic lateral ankle instability [4], and the Broström–Gould procedure uses the remaining anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL) tissue augmented by local extensor retinaculum [5], allowing restoration of stability [4]. But when a large ossicle is present within the lateral ligaments, removal of the ossicle can result in a lack of remnant ligamentous tissue and leave a gap within the ATFL and CFL that may not be approximated [6]. These conditions can be the indications for lateral ankle ligament reconstruction augmented by an allograft or autograft tendon. So contraindications have now been suggested after further experience with this direct ligament repair, including failed previous reconstructive surgery, the presence of long-standing ankle instability, generalized

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ligamentous laxity or increased size or weight. Remnants of the ruptured ligaments degenerate over time and are therefore sometimes inadequate for use as reconstructive material because of both their low tensile force and shortening with respect to normal length [7,8].

Treatment of CLAI via anatomic reconstruction with an allograft leads to a high degree of patient satisfaction, decreased pain, a stable ankle with minimal degenerative changes, and significantly improved function [9]. However, potential allograft complications include disease and infection transmission, delayed graft remodeling and graft-bone incorporation, subclinical immune responses, and increased cost [10,11].

Autografts used to treat CLAI have included the semitendinosus [12], gracilis [8,13], plantaris, palmaris [14], peroneus brevis [15] and longus tendons [16], the fascia lata, and the patellar tendon [17]. Injury to the anterior talofibular ligament (ATFL) and the calcaneofibular ligament (CFL) causes varus instability of the ankle joint. When the peroneus brevis tendon is cut to reconstruct the lateral ligament, valgus power is weakened, and the subtalar and ankle joint activity will be limited. In the short-term, patients undergoing this procedure have experienced subtalar stiffness and non-physiologic kinematics, and long-term follow-up found that 19%–28% of patients will experience ankle arthritis [18,19]. Reconstruction of the lateral ankle for CLAI using a gracilis graft has reportedly achieved good results [8,13,20]. However, the ankle surgeon must have extensive knowledge of the anatomy of the knee to avoid inadvertent saphenous nerve injury during harvesting of the gracilis graft [21,22].

The AHPLT is an alternative autograft source that reportedly has acceptable strength, safety, and donor site morbidity. Furthermore, Zhao and Huangfu [23] found that cutting the peroneus longus tendon had no effect on ankle joint stability. Previous studies have reported that use of the AHPLT to reconstruct the lateral ligament has achieved good results [16]. However, the ideal reconstruction procedure should restore normal ankle motion and stability while maintaining proper hindfoot biomechanics. In the present study, we performed reconstruction of the lateral ligament and simultaneously connected the talus and cuboid to replace the role of the ligamentum bifurcatum and thus stabilize the Chopart joints, which better stabilizes the midfoot and hindfoot.

The purpose of this study was to evaluate the function of the ankle joint after ligament reconstruction and to correlate the results with both the patient's subjective symptoms and the objective results of follow-up clinical and radiographic examination.

2. Materials and methods

This retrospective study included 32 consecutive patients (32 ankles) with CLAI who underwent lateral ankle ligament reconstruction using the AHPLT performed by two of the authors from January 2013 to December 2014. The institutional review board approved the study, and all patients provided informed consent for study inclusion.

Inclusion criteria: history of CLAI for more than 6 months with pain, repeated episodes of ankle collapse, and swelling; positive anterior drawer test on physical examination; evidence of ankle instability on clinical or radiographic examination [2,24,25].

Exclusion criteria: combined medial (deltoid ligament) and lateral ankle instability; local infection of the ankle joint; fracture of the tibia, fibula, talus, or calcaneus (except for the ankle avulsion of small bones) [26]. Contraindications to this surgery included congenital collagen deficiency, bodyweight over 120 kg, severe heart disease, lesions affecting liver and kidney function, severe diabetes, central nervous system diseases, and other medical diseases.

All included CLAI patients underwent lateral ankle ligament reconstruction using the AHPLT. Eighteen of the 32 patients (56.3%) were male, and 14 (43.7%) were female. The average age at the time of surgery was 31.9 (range, 18–43) years. The left foot was involved in 24 cases (75%), and the right in 8 cases (25%). Median follow-up duration was 28 (range, 24–35) months.

Pre- and postoperative evaluation included history taking and physical examination, including the talus tilt test and anterior

Fig. 1. Intraoperative testing of anterior drawer (A1, A2) and talar tilt (B1, B2) in a male patient with chronic lateral ankle instability of the right ankle. (A1) The right ankle had a positive anterior drawer sign. (A2) The left ankle had a negative anterior drawer sign. (B1) The right ankle had a positive talar tilt. (B2) The left ankle had a negative talar tilt.

drawer test. Radiologic examinations were performed preoperatively and during final follow-up. The patients were examined for the presence of structural ligament insufficiency; these tests may be negative when there is only functional ankle instability [27]. Ankle instability was indicated by a talar tilt angle of greater than 9°, or more than 3° variation between the left and right sides. The anterior drawer test was considered to be positive when stress radiographs and anterior drawer testing showed that the forward movement of the talus was greater than 10 mm, or moved more than 3 mm compared with the contralateral side (Fig. 1) [8,15,16,28,29].

3. Operative procedures

Epidural anesthesia was administered, and the patient was placed in supine position with a thigh tourniquet. For comparison, the same tests were performed on the contralateral side; this comparative practice proved that the method used to assess ankle stability was effective. A curvilinear incision was then made approximately 7 cm below the lateral malleolus and along the peroneal muscle (Fig. 2 ①). The lateral ankle and sinus tarsi were exposed, while taking care to protect the sural nerve and its branches. The peroneal tendon sheath was identified, and the tendons were examined for tears. The ATFL and the CFL were checked for relaxation or complete rupture due to avulsion fracture (Fig. 2 ②). At the proximal end of the incision, the peroneal longus muscle was located on the surface of the peroneal brevis muscle. The peroneus longus tendon was then pulled out through the incision with a hemostatic clamp, and the anterior half of the tendon was cut and split (Fig. 2 ③); the tendon was sutured with 2.0 absorbable suture material (Polysorb Braided Absorbable Suture, Covidien, USA). A second 1.0 cm longitudinal incision was made over the peroneus longus tendon 10 cm proximal to the initial incision. The AHPLT (about 10 cm in length) was pulled out through the second incision and cut (Fig. 2 ④). The tip of the lateral malleolus was drilled above the central level, approximately from front to back, through the fibula. Three 5 mm diameter holes were drilled 15 mm deep at the ATFL insertion point of the talus, the CFL at the calcaneal insertion and the central cuboid. The harvested tendon was passed through the fibular tunnel, and the anterior end of the tendon was fixed into the cuboid tunnel with a 5.0-mm resorbing screw (Depuy Mitek, USA). To maintain ankle joint varus of 35° and flexor tendon function, the other end of the harvested tendon was fixed into the calcaneal tunnel at the CFL attachment area with a 5.0-mm resorbing screw (Depuy Mitek, USA) to reconstruct the CFL (Fig. 2 ⑤⑥⑦). The graft was sutured to the talus at the ATFL attachment area, to the anterior border of the lateral malleolus, to the inferior pole of the lateral malleolus, and to the calcaneus with the ankle in a plantigrade neutral position (Fig. 2 ⑧⑨) (Fig. 3). The incision was then rinsed with saline and sutured. The ankle joint was fixed in neutral position by lower leg plaster casting.

At 14 days postoperatively, the sutures were removed, and a short leg cast was applied in a neutral position for 4 weeks without weight bearing. Four weeks after surgery, active range of motion and partial weight bearing was allowed with a soft ankle orthosis. Gradually, full weight bearing was allowed. Balance training and proprioceptive exercises were encouraged.

3.1. Efficacy evaluation criteria

Patients were asked to rate their overall satisfaction with their surgical results as ‘excellent’, ‘good’, ‘fair’, or ‘poor’ (Table 1) [15]. Outcomes were assessed by comparison of pre- and postoperative American Orthopaedic Foot and Ankle Society (AOFAS) scores, visual analog scale (VAS) pain scores, and Karlsson scores. All patients underwent pre- and postoperative radiographic assessment including talar tilt and anterior talar translation.

4. Statistical analysis

The statistical analysis was performed using the data analysis program SPSS Statistics version 16.0 software (SPSS Inc, Chicago, Illinois, USA). Data normality was assessed by the

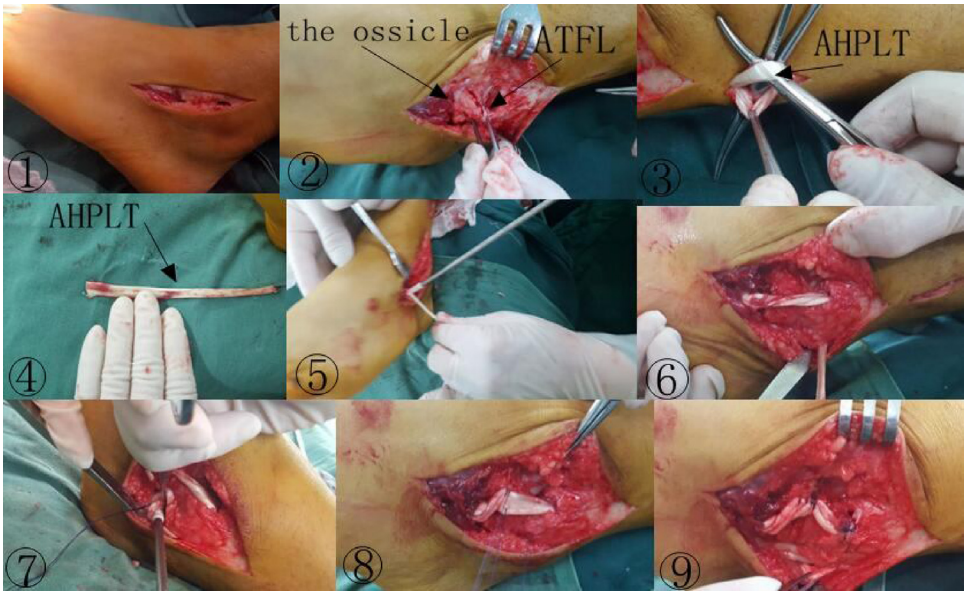

Fig. 2. Intraoperative photographs of the anterior half of the peroneus longus tendon (AHPLT) transfer procedure. ① A 7-cm incision was made distally from the lateral malleolus. ② Patients were checked for anterior talofibular ligament (ATFL) laxity and avulsion fracture. ③ ④ The peroneus longus tendon was then pulled out through the incision with a hemostatic clamp, and the AHPLT was cut and split. ⑤⑥⑦ The harvested tendon was passed through the fibular tunnel, and the anterior end of the tendon was fixed into the cuboid tunnel with a 5.0-mm resorbing screw (Depuy Mitek, USA). To maintain ankle joint varus of 35° and flexor tendon function, the other end of the tendon was fixed into the calcaneal tunnel at the calcaneofibular ligament (CFL) attachment area with a 5.0-mm resorbing screw (Depuy Mitek, USA) to reconstruct the CFL. ⑧⑨ The graft was sutured to the talus at the ATFL attachment area, to the anterior border of the lateral malleolus, to the inferior pole of the lateral malleolus, and to the calcaneus with the ankle in plantigrade neutral position.

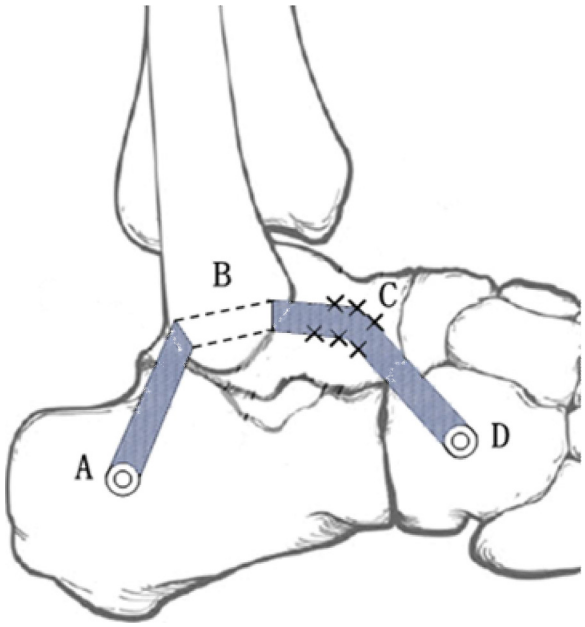

Fig. 3. Schematic drawing of the surgery method. A: The anterior half of the peroneus longus tendon (AHPLT) was fixed into the calcaneal tunnel. B: The AHPLT crossed the fibula. C: The AHPLT was sutured to the talus at the ATFL attachment area. D: The AHPLT was fixed into the cuboid tunnel.

Kolmogorov–Smirnov test. The paired *t*-test and Wilcoxon's signed-rank test were used to compare pre- and postoperative values (AOFAS ankle-hindfoot scores, VAS scores, Karlsson ankle scores, and radiologic measurements). Statistical significance was accepted for P values < 0.05.

5. Results

Postoperatively, all 32 patients (32 ankles) (100%) returned for final evaluation. Overall patient satisfaction was rated as excellent by 27 (84.4%) patients, good by 3 (9.4%) patients, and poor by 2 (6.3%) patients. No patient rated their outcome as fair.

One patient who was dissatisfied with the result had undergone a rapid increase in bodyweight (Preoperative, the weight was 73 kg, the last follow-up, the weight was 98 kg) and did not complete the rehabilitation training; this led to ankle stiffness and an inability to return to the previous level of sports activity. However, the patient had achieved mechanical stability on ankle stress radiographs. After 2 months of correct guidance and physiotherapy, the ankle stiffness had markedly improved. The other patient who was dissatisfied with the result had fallen down some stairs 1 month postoperatively, which resulted in calcaneal fractures. This patient returned to the hospital for open reduction and internal fixation of the calcaneal fractures, and recovered well after the second surgery.

At the time of final follow-up, 29 patients (29 ankles) were pain free and 3 ankles were mildly painful after exercise with morning stiffness, but there was no difficulty walking on even ground. The VAS pain score was significantly reduced from 5.5 (range, 4–7) points preoperatively to 0.5 (range, 0–3) points at the last follow-up. The mean preoperative AOFAS score (59.6 ± 6.0) improved significantly to a mean postoperative score of 92.8 ± 4.9. The Karlsson score significantly improved from 55.7 ± 7.9 points preoperatively to 92.1 ± 7.7 points at final follow-up. Mechanical stability was achieved. The mean talar tilt angle significantly improved from $14.1 \pm 4.2^\circ$ preoperatively to $3.4 \pm 1.3^\circ$ at final follow-up, and the mean anterior talar translation significantly improved from 13.8 ± 3.4 mm preoperatively to 3.6 ± 1.5 mm at final follow-up (Table 2).

6. Discussion

The purpose of this study was to assess the result of reconstruction of the lateral ankle ligament using the AHPLT for treatment the CLAI. Our hypothesis was that patients presenting with complex or recurrent mechanical CLAI would achieve satisfactory results after reconstruction with an autograft tendon, and would achieve mechanical stability without serious complications. The results of the current study in a series of 32 ankles are encouraging, with 30 of 32 (93.8%) patients reporting excellent or good results using the AHPLT for reconstruction.

We found that many patients with ankle instability also had subtalar instability. If we only repair the ankle joint and ignore the subtalar lesions, patients will still experience postoperative insecurity, instability, and 'giving way' on uneven ground. This is because subtalar stability plays a very important role when walking on uneven ground [30], and 40.5% of patients with CLAI have clinical signs of damage to the ligamentum bifurcatum of the midfoot, which can result in laxity in the lateral part of the transverse tarsal joint (Chopart's lateral joint line) [31,32]. Therefore, we believe that the goal of surgical reconstruction should include the restoration of ankle joint, subtalar joint, and Chopart lateral stability.

Table 1
Clinical rating scale for postoperative ankle reconstruction [16].

Rating	Description
Excellent	Full range of motion equal to the contralateral ankle without pain. Able to return to the preinjury level and unrestricted work or sports activity
Good	Functional range of motion and stable ankle. Able to return to the preinjury level with minimal pain with work or sport activity
Fair	Functional range of motion, good stability, moderate level of pain, and/or stiffness with activities of daily living and sports activity
Poor	Persistent instability or pain, the same or worse than before surgery

Table 2
Preoperative and final follow-up values of the assessed variables (n = 32).

Index	Preoperative	Last follow-up	Test statistic	P value
Anterior displacement (mm $\bar{x} \pm s$)	13.8 ± 3.4	3.6 ± 1.5	15.622	$P < 0.001$
Talar tilt angle ($^\circ$ $\bar{x} \pm s$)	14.1 ± 4.2	3.4 ± 1.3	13.636	$P < 0.001$
AOFAS ankle-hindfoot (points)	59.6 ± 6.0	92.8 ± 4.9	−24.182	$P < 0.05$
Karlsson (points $\bar{x} \pm s$)	55.7 ± 7.9	92.1 ± 7.7	−18.641	$P < 0.05$

AOFAS: American Orthopaedic Foot and Ankle Society.

At present, CLAI reconstruction is performed via the use of the autograft tendon method to fix the ligament in the talus and calcaneus. The application of the AHPLT graft not only fixed the calcaneus and fibula, and the talus and the fibula, but also fixed the talus and the cuboid. Lateral ankle stability is thus maintained by the tension of the ATFL and CFL tendons, and reconstruction of the ATFL and CFL is equivalent to the original anatomical structure of the human body; this fully stabilizes the ankle joint and subtalar joint. When the talus and cuboid are connected, this can play the role of the ligamentum bifurcatum, and thus stabilize the Chopart joints, which can better stabilize the midfoot and hindfoot.

The ligamentum bifurcatum injury leads to foot swelling and pain. The ligamentum bifurcatum is a major stabilizing factor for the lateral side of the Chopart joints, and it also stabilizes the midfoot and hindfoot to provide the main static support of the lateral and medial columns [32]. It is therefore recommended that patients with a history of ankle sprain be evaluated for damage to the ligamentum bifurcatum of the midfoot [31].

In the past, autograft tendon reconstruction of the ankle lateral ligament has been conducted using the peroneus brevis tendon; the role of the peroneus brevis tendon is to stabilize the ankle, maintaining foot valgus. Krips et al. reported that the peroneus brevis tendon reconstruction is a destructive surgical procedure that limits the activities of the ankle and subtalar joints [19]. Furthermore, Otis et al. performed foot gait analysis and a cadaver study of the peroneus longus and brevis tendons and found that the peroneus brevis tendon maintains the effect of valgus to a greater degree than the peroneus longus tendon, which is the main tendon that maintains valgus [33]. The AHPLT is reportedly an acceptable alternative autograft source in the treatment of anterior cruciate ligament injury [23,34]. Zhao and Huangfu [23] found that resection of the peroneus longus tendon had no effect on foot and ankle function. As the same surgical incision is used to harvest the peroneus brevis tendon and the peroneus longus tendon, we chose to use the peroneus longus tendon to perform reconstruction in treatment of ankle instability to avoid excessive foot varus.

However, this study is limited by its retrospective, no control group was included for comparison purposes, the small sample size. Also, the senior surgeon performed subjectively the clinical evaluations including mechanical and functional stabilities, introducing the possibility of evaluation bias. Further research is warranted to confirm the present findings.

7. Conclusion

AHPLT transfer to reconstruct the lateral ligament and ligamentum bifurcatum resulted in a high percentage of successful results, with excellent ankle stability and not affected of ankle motion. This surgical technique is simple, reliable, and stable. So the method is worthy of clinical promotion.

Disclosure of conflict of interest

All the authors declare that they have no conflict of interest.

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