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# Ankle Lateral Ligament Reconstruction in Skeletally Immature Patients: Technique Tip

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**Keywords:** Chronic lateral ankle instability, ankle sprain in children and adolescents, skeletally immature patients, open growth plate/physis, ankle re-injury/revision

## Introduction

Lateral ankle instability remains a common lower extremity injury in active patients, including children and adolescents. Chronic lateral ankle instability (CLAI) may develop after sustaining an ankle sprain, despite nonoperative treatment.[7] A systematic review of the prevalence of CLAI showed perceived instability in children with a history of ankle sprain to be 23% to 71% and mechanical instability to be 18% to 47%. In comparison to the adult population, the incidence of CLAI is considered similar, or even higher in children and adolescents.[10] In pediatrics, fibular physis closure occurs at age 12-17 years in females and 15-20 years in males.[5] An iatrogenic disturbance can theoretically lead to physeal damage or growth arrest. These growth plate injuries in growing children can cause joint misalignment and future ankle arthritis. Therefore, the surgeon must carefully consider the open growth plate during surgery.

Direct repair is generally performed in cases where conservative treatment fails while reconstruction using autograft/allograft tendons or artificial ligaments is indicated when the remaining ligament has severely degenerated or disappeared, or for cases of recurrence after direct repair.

Most available studies have focused on skeletally mature adolescent and adult patients or anatomic repair and nonanatomic reconstruction for pediatric patients that involve fixing the transplanted tendon within a bone tunnel created in the fibula.[4] When performing these procedures on skeletally immature patients, there is a high risk of damaging the growth plate. Our study aims to provide a technical tip for revision anatomic reconstruction of the lateral ankle ligaments using a hamstring autograft in skeletally immature patients.

## Technique

### *Positioning and Equipment*

Patient is in supine position on a fluoroscopy-compatible table. An arthroscopy set, motorized shaver, hamstring graft harvester, graft sizer, cannulated drill, guide pins, and a nonsterile tourniquet is prepared. Two Q-FIX MINI all-suture anchors (Smith & Nephew, Memphis, TN) are used on the fibular side. The talar and calcaneal sides are each fixated with a 20 mm × 6 mm Osteotrans Plus Biocomposite Interference Screw (Zimmer Biomet, Warsaw, IN).

### *Arthroscopic Examination*

Arthroscopic examination is suggested prior to reconstruction to view other possible concomitant pathologies.

### *L-Shaped Hamstring Autograft Construction*

A 115-mm-long and 6-mm-wide hamstring (gracilis) autograft tendon is harvested (Figure 1).

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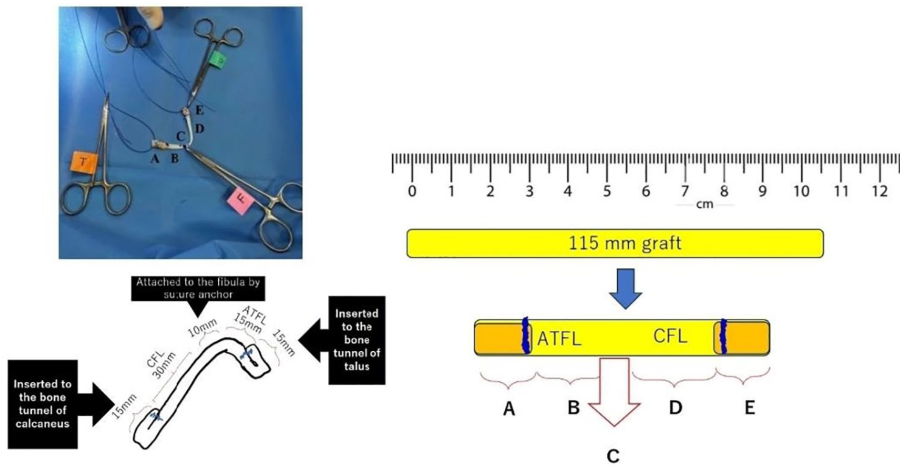


**Figure 1.** To prepare the anatomic L-graft, the harvested tendon is folded on itself at both ends (15 mm from the end), and a traction suture is passed through the loop made on each end. The talar limb (A) enters into the talar bone tunnel, (B) becomes the anterior talofibular ligament, (C) is attached to the fibular footprints by 2 suture anchors, (D) becomes the calcaneofibular ligament, and (E) leads to the calcaneal limb that enters into the calcaneal bone tunnel.

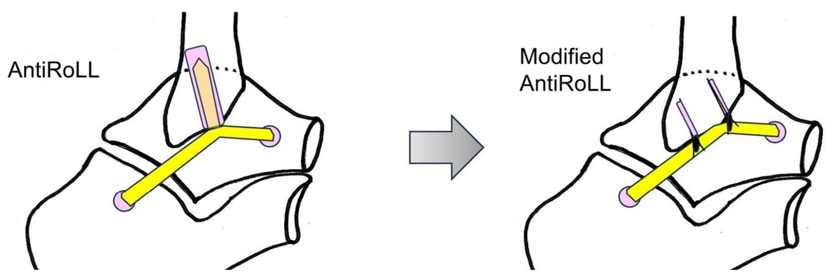


**Figure 2.** Illustration of ankle anatomical reconstruction of the lateral ligament (ankle AntiRoLL) in comparison to the modified AntiRoLL technique performed to address chronic lateral instability of patients with open distal fibular physis.

## *Anatomic Anterior Talofibular Ligament and Calcaneofibular Ligament Reconstruction Using L-Shaped Hamstring Autograft*

*Modification of the ankle arthroscopic reconstruction of the lateral ligaments (ankle AntiRoLL)*[15]. The AntiRoLL technique makes use of interference screw fixation via construction of 3 bone tunnels (fibula, calcaneus, and talus). Our modified AntiRoLL technique is used in consideration of the patient's open distal physis. Instead of a bone tunnel created on the fibular side, 2 suture anchors are used (Figure 2).

*Anatomical footprint of the anterior talofibular ligament and calcaneofibular ligament.* The fibular obscure tubercle (FOT) may be used as the main landmark for the origin of the anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL).[11] It is located between the footprint center of the ATFL and CFL origin of the fibula. Matsui et al[11] found that the ATFL origin of the fibula is located 3.7 mm (range 0-6.7 mm) proximal to the FOT, while the CFL origin footprint on the fibula is located 4.9 mm (range 1.1-10.9 mm) distal to the FOT. The ATFL insertion is 59.6% distal from the anterolateral corner of the talar body on the line connecting the anterolateral corner of the talar body and the distal end of the lateral talar process. At the same time, the CFL is 17.2 mm distal from the surface of the posterior talocalcaneal joint on the perpendicular bisector line of the talocalcaneal joint in the lateral view to the joint of the tendon sheath of the peroneus longus and brevis.[11] This anatomical footprint guides the talus and calcaneus' suture anchor placement and bone tunnels.

*Anatomic ATFL/CFL reconstruction surgical steps*

**Step 1:** After skin marking of the lateral malleolus and tibiotalar joint line, a 3-cm arcuate incision is made along the anterior margin of the lateral malleolus located just immediately distal to the tibiotalar joint line (Figure 3).


**Figure 3.** Skin marking at tibiotalar joint line and lateral malleolus (LM). A 3-cm arcuate incision is made just distal to the tibiotalar joint line and anterior to the lateral malleolus.

**Step 2:** The bone tunnel is created at the talar insertion of the ATFL (Figure 4). When creating the talar bone tunnel, the guidewire is inserted from the **lateral to medial direction**, starting at the ATFL talar footprint with a wire directed toward the tip of the medial malleolus piercing through the medial skin. Michels et al[12] conducted a cadaveric study of guidewire insertion direction and has reported that insertion toward the tip of the medial malleolus was the safest. An excessively anterior guidewire insertion will break through the anterior wall of the talus, whereas an excessively posterior insertion will risk damaging the tibial nerve or posterior tibial artery. Overdrilling the pilot hole by 20 mm × 6 mm **from the lateral to medial direction** is performed using a guidewire under fluoroscopic guidance, followed by use of a guide suture and passing of suture graft. A 6-mm-diameter, 20-mm-length cannulated interference screw is then passed over its guide pin and screwed into the talus until the base of the screw is no longer visible. The guidewire is then removed.

**Step 3:** A bone tunnel is created at the calcaneal insertion of ATFL (Figure 5). From the lateral gutter toward the calcaneal attachment of the CFL, blunt dissection is performed between the bone and soft tissue with a mosquito clamp facing toward the posterior talocalcaneal joint. The clamp is passed along the lateral wall of the calcaneus, retracting the peroneal tendons laterally and superficially. Fluoroscopy check ensures that the tip of the guidewire is facing toward the posterior inferior medial edge of the calcaneal tuberosity, which penetrates the calcaneus at a point 10 mm distal from the posterior talocalcaneal joint while perpendicular to the posterior facet. The guidewire is then inserted into the calcaneus at an angle of approximately 40 degrees from midline, pointing toward the heel midline and penetrating the skin plantarly.

**Step 4:** Two suture anchors are then fixated on the anatomical footprint of the ATFL and CFL at the fibular side using the FOT as a landmark (Figure 6). A pilot hole is created from the ATFL footprint directed posteriorly at an angle of 45 degrees in respect to the longitudinal axis of the fibula using a suture anchor (Q-FIX MINI; Smith & Nephew, USA) with a shorter length (17.1 mm) than conventional anchors (22.3-25 mm) while avoiding physeal injury followed by the CFL anatomic insertion. The ATFL and CFL attachments of tendon grafts to the fibula (zone C, Figure 1) are subsequently sutured to each suture anchor with a modified lasso-loop stitch (Figure 7). Finally, both loop-ended grafts are passed through their corresponding bone tunnels and fixed with separate interference screws (Figure 8).

### *Postoperative Plan*

The operative limb is immobilized with an elastic bandage for 2 days. Partial weightbearing is allowed the day after surgery and full weightbearing 1 week after. Single heel raise, proprioceptive training, and treadmill running is allowed at 3 weeks after surgery. Single leg jumping and sports-specific training is started 6 weeks after surgery. Progression of rehabilitation should be adjusted on a case-to-case basis.

## Discussion

Recurrent ankle instability or chronic reinjury typically warrants surgical stabilization, even in children and adolescents.[3,7,9,10] Traditionally, there have been several known techniques to address recurrent ankle instability in pediatrics, including (1) *anatomical repairs*, which is a direct end-to-end repair of the ruptured ATFL first described by Broström et al,[1] imbrication or shortening of the ATFL/CFL, or the inclusion of the extensor retinaculum and periosteum of the fibula in the repaired ATFL (Gould modification) among others,[9] and (2) *nonanatomic reconstruction*, which restores ankle stability by commonly using a local tendon transfer or more commonly the peroneus brevis tendon graft that is routed to the fibular suture or bone tunnel (Evans), using the peroneus brevis tendon graft that is routed through the fibula and talus to reconstruct the ATFL and CFL (Watson-Jones), splitting the peroneus brevis tendon that is routed to the calcaneus and fibula (Chrisman-Snook), or other variations of these techniques thereof. These techniques are all considered nonanatomic reconstruction, because it does not follow the true anatomic insertions of the lateral ankle ligaments.[2]

However, reinjury and revision surgery eliminate the option to consider anatomic repair because of severely

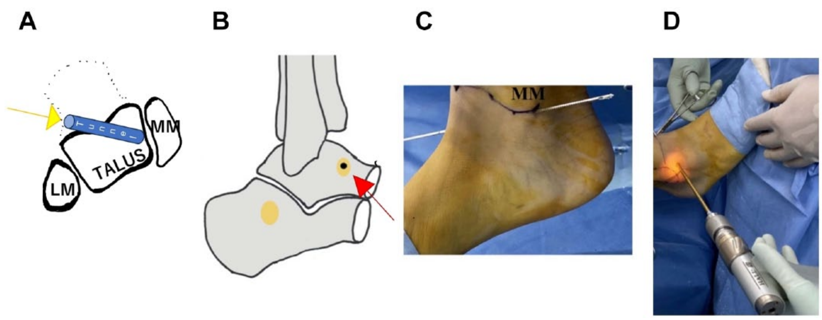


**Figure 4.** Talar bone tunnel creation. The axial cut of the talus and yellow arrow indicate the direction of talar tunnel insertion of the ATFL (A) on the lateral view of the ankle (red arrow pointing at the talar ATFL footprint) (B). A clinical photograph shows the exit of the guidewire just below the medial malleolus (C), followed by overdrilling the talar tunnel from the lateral to medial side (D). ATFL, anterior talofibular ligament.

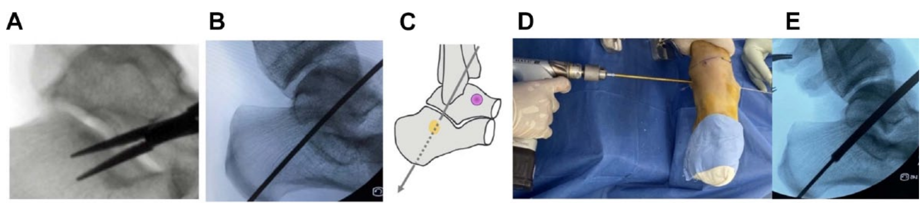


**Figure 5.** Creation of calcaneal bone tunnel. From the lateral gutter toward the calcaneal attachment of the CFL, a blunt dissection is performed between the bone and soft tissue with a mosquito clamp toward the posterior talocalcaneal joint that is passed along the lateral wall of the calcaneus, retracting the peroneal tendons laterally and superficially (A). Fluoroscopic observation ensures that the tip of the guidewire faces toward the posterior inferior medial edge of the calcaneal tuberosity (B), which penetrates the calcaneus at a position 10 mm distal from the posterior talocalcaneal joint while perpendicular to the posterior facet (C). The guidewire is inserted into the calcaneus at an angle of approximately 40 degrees from the midline, pointing toward the heel midline and penetrating the skin plantarly. Overdrilling the calcaneal tunnel is performed with 20 mm depth and 6 mm width (D and E). CFL, calcaneofibular ligament.

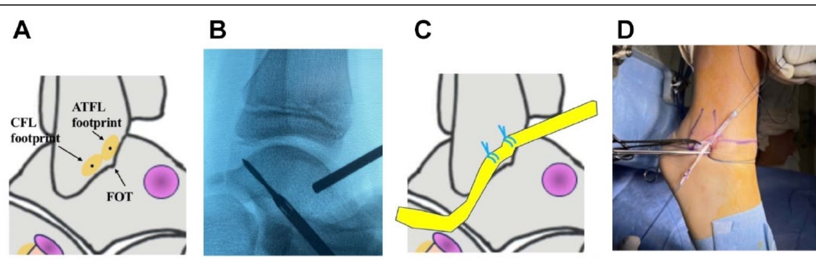


**Figure 6.** The ATFL and CFL footprints are identified using the fibular obscure tubercle (FOT) as a landmark (A). A pilot hole is created from the ATFL footprint that is directed posteriorly at an angle of 45 degrees in respect to the longitudinal axis of the fibula using a suture anchor (Q-FIX MINI; Smith & Nephew, USA). The anchor is of shorter length (17.1 mm) than conventional anchors (22.3-25 mm) and is inserted while avoiding physeal injury (B), followed by the CFL insertion. The ATFL and CFL attachments of tendon grafts to the fibula were subsequently sutured to each suture anchor with a modified lasso-loop stitch (C and D). (See also Figure 7.)[5-7] ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament.

attenuated or absent ligaments. Although nonanatomic reconstruction may be a surgical option in providing a biomechanically stable ankle joint, it poses several disadvantages such as sacrificing the peroneus brevis, which results in weak peroneal function, risk of growth plate injury while drilling for bone tunnels, and lastly, potentially restricting the subtalar joint movement.[9] All of these techniques may potentially affect sports performance in young athletes.

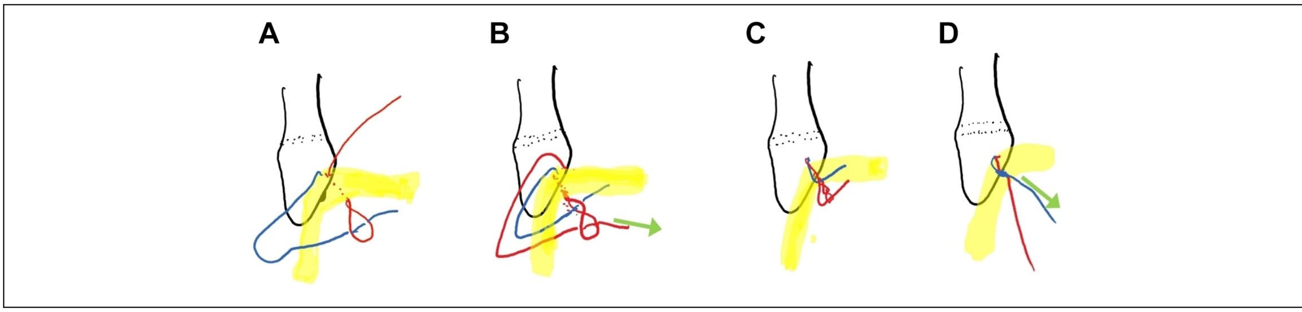


**Figure 7.** The first suture thread (red) is passed behind the graft but not completely to make a loop. The loop is then rotated half a turn, and the second suture thread (blue) passes into this first loop (A). The loop is rotated again half a turn to form a second loop and the first suture thread (red) on the same side as the loop that is passed through the second loop that was created (B). The end of the first suture thread (red) is pulled, and the loop is tightened to create a small loop but not completely tightened (C). The end of the second suture thread (blue) on the opposite side of the loop is pulled while the ankle is set at 0 degrees neutral position and sliding the knot close to the suture anchor. Then, the stump of the remaining ligament is pushed onto the fibular attachment using a knot pusher, and the thread is simultaneously slipped in the nodule with the knot tightened firmly (D).

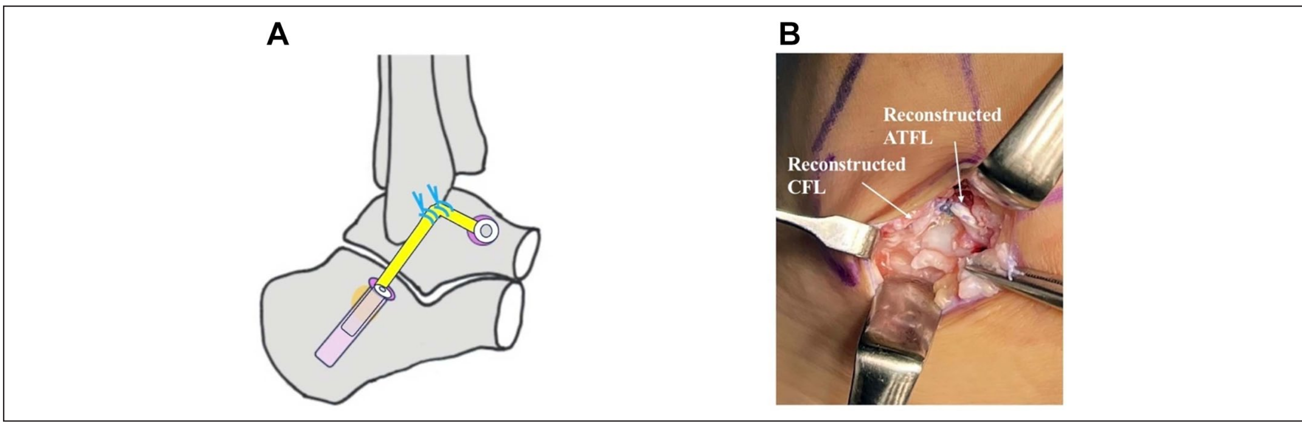


**Figure 8.** Animated illustration of the reconstructed ATFL and CFL using a hamstring autograft (A) and actual reconstructed ATFL and CFL (B). ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament.

*Anatomic reconstruction* using a hamstring allograft or autograft would be a good option for a young patient with a high athletic level and chronic lateral ankle instability. Modifying the AntiRoLL technique[15] is helpful for patients presenting with open distal fibular physis. This modified technique addresses potential injury to the growth plate.

Hazratwala et al[6] recommended a preoperative measurement of the open physis to distal tip of the fibula on radiograph/CT scan or use of intraoperative fluoroscopy to determine if the growth plate is at risk, because the measurement of the growth plate from the tip of the fibula can be less than 22 mm in 20% of their studied patients.[6] We use Q-FIX MINI (Smith & Nephew, USA) with a shorter bone hole length (17.1 mm). By drilling the fibular footprint of the ATFL obliquely from an anteroinferior to posterosuperior direction at an angle of 45 degrees against the long axis of the fibula under fluoroscopic guidance, the pilot hole could be maintained distal to the epiphysis without penetrating the physis (see Figure 6B). Therefore, risk for growth plate injury is unlikely with careful attention paid to the penetration depth.

The lasso-loop stitch is one of the self-cinching stitches.[8] Previous studies have shown that they have superior tissue-holding strength when compared with equivalent non-self-cinching stitches, and it is widely used with good clinical results in shoulder surgery to aid margin convergence in rotator cuff repairs and also used as traction sutures during stabilization procedures.[13] It has already been applied to repair procedures for the lateral ankle ligament, and clinical results have proven that recurrence is extremely rare.[14,16,17]

## Conclusion

Modification of the AntiRoLL technique is useful for patients presenting with open distal fibular physis. This modified technique avoids potential injury to the growth plate and its consequent complications. It is an anatomical fixation with the advantage of physiologic, mechanical, and clinical stability, especially important in a young, active patient.

## Ethical Approval

All patients provided their written informed consent to participate in this study, which was approved by the Ethics Committee of the Japan Medical Association (approval number: R1-6).

## Declaration of Conflicting Interests

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