Technical Note

Single Knotless Suture Anchor Repair of Anterior Talofibular Ligament Following Distal Fibula Nonunion Excision

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Abstract: Anterior talofibular ligament (ATFL) tear is the most common ankle ligament injury. This can lead to recurrent ankle instability, which is detrimental to ankle function and the patient's quality of life. Currently, several techniques have shown successful outcomes for ATFL repair. In this technical note, we describe an open ATFL repair using a single knotless suture anchor at the distal fibula location. This approach is rapid, equipment-efficient, and reproducible, while promising excellent results and high patient satisfaction by restoring ATFL anatomy.

Introduction

Ankle ligament sprain is a common injury in sports medicine, comprising 20% to 40% of all athletic injuries and is also highly prevalent in general medical practice with ∼27,000 daily cases reported in the United States.[1,2] The most common mechanism of ankle injury involves ankle inversion at a high velocity, leading to lateral ankle sprains, and subsequently, ankle instability.[3] Lateral ankle sprain can cause avulsion fractures, most commonly avulsion of the distal fibula, which is the attachment site of several ligaments.[4,5] Patients with avulsion fractures have a higher risk of recurrent ankle sprains.[6] If left untreated, distal fibula fractures may become nonunion and persist as subfibular ossicles, which may cause chronic ankle pain and instability.[7]

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This pathology may result in limited athletic activity and may increase the risk of ankle osteoarthritis in the long term.[8] Symptomatic nonunion fractures can be treated surgically by excising the nonhealing fragment. However, this procedure alone might further compromise the integrity of the ligament that is responsible for the avulsion fracture.[9] Therefore, it is crucial to repair the ankle ligament following the removal of the distal fibular nonunion fragment.

Among the ligaments that attach to the distal fibula, the anterior talofibular ligament (ATFL) is the weakest, and thus, the most vulnerable to ankle injuries.[2,5] ATFL injury is often treated successfully with nonoperative treatments, such as rest, ice, elevation, compression, and physical therapy. However, 20-25% of people who choose conservative treatments still suffer from recurrent lateral ankle instability, so surgical intervention becomes necessary to prevent further complications.[10,11] To manage ankle instability, various surgical techniques have been developed and can be categorized into two broad groups: anatomic repair/reconstruction and nonanatomic reconstruction. Anatomic repair and reconstruction of the ATFL aim to closely replicate the native anatomy of the ATFL, while restoring the mechanics and functions of the ankle and subtalar joint. Nonanatomic reconstruction involves the use of tendon grafts to tighten and strengthen the lateral ankle without repairing the ATFL. The objective of this technical note and the accompanying video is to detail an anatomic repair of the ATFL employing a single knotless suture anchor following the distal fibula nonunion excision. This technique is simple and time-

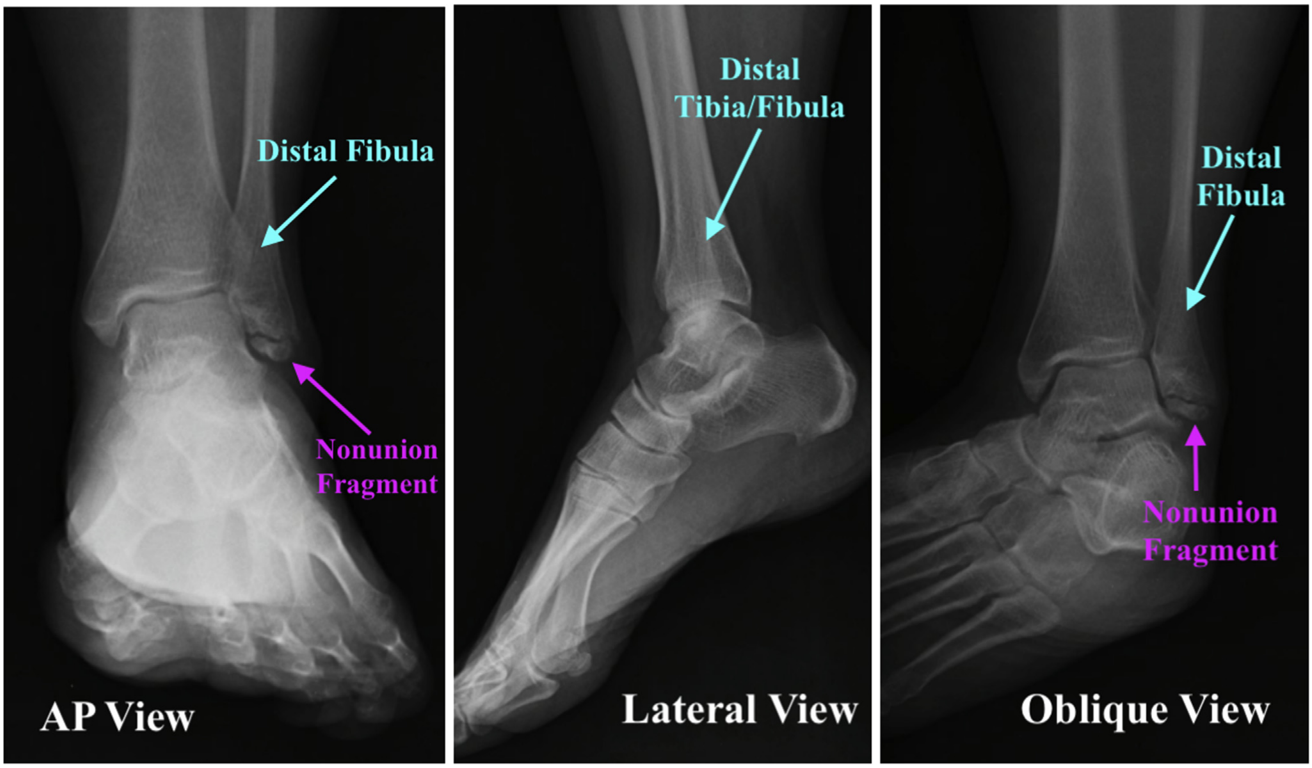

Fig 1. Preoperative radiograph images of the left ankle in the anterior-posterior (AP), lateral, and oblique views. In the AP and oblique view, a bone fragment is noted on the distal end of the fibula with no callus formation around the fragment. No osseous abnormality is noted on the lateral view. These radiograph images are significant indications for a nonunion of the distal fibula, with no evidence of healing.

efficient, while still anatomically securing the ATFL to the distal fibula.

Surgical Technique

Preoperative Assessments

Clinical Evaluation

When performing preoperative assessment, it is imperative to obtain a detailed history to elucidate the nature and the mechanism of the ankle injury as ankle inversion is the common cause of ATFL injury and distal fibular avulsion fracture. Subsequently, a careful clinical evaluation should be conducted to assess for abnormality, edema, ecchymosis, and tenderness to palpation of the lateral ankle. A limited ankle range of motion may be indicative of joint effusion. Physical examination should include special tests such as ankle anterior drawer test, which assesses the integrity of the ATFL, and talar tilt test, which indicates ATFL and calcaneofibular ligament rupture. The goal is to identify the injured anatomical structure and the associated injuries, such as avulsion fracture and neurovascular injury, while evaluating the severity of the injury.

Radiograph

Radiographs of the ankle are obtained in the anterior-posterior (AP), lateral, and oblique views to evaluate for osseous abnormalities, such as avulsion fracture and syndesmosis widening (Fig 1). Magnetic resonance imaging can be used to confirm the fracture and to evaluate the ankle ligaments' integrity.

Indications of Surgery

The indications of surgery include persisting pain, recurrent ankle sprains, symptomatic avulsion fracture, and reduced quality of life, despite attempts with conservative treatments.

Patient Positioning and Preparation

Once general anesthesia is induced, the patient is positioned supine on the operating table with a bump under the ipsilateral hip. A tourniquet is placed on the thigh of the ipsilateral extremity. The head and bony prominences of the patient are well padded, and the lower extremity is prepped and draped in a sterile fashion.

Distal Fibula Nonunion Excision

The landmarks are marked and identified, including the lateral malleolus and the approximate location of the superficial peroneal and sural nerves. The tourniquet is inflated to 250 mmHg. Prior to incision, fluoroscopic images are taken to confirm visualization and

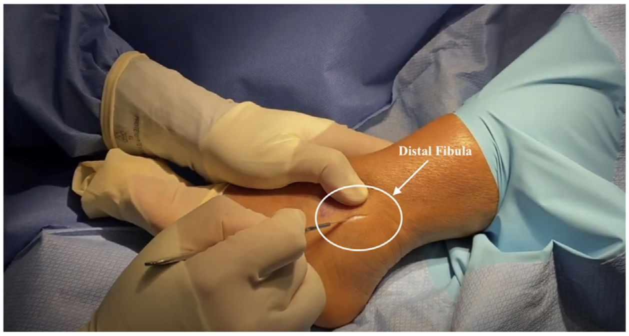

Fig 2. Incision over distal fibula. The patient is positioned supine on the operating table with the left ankle internally rotated. The incision is made over the prominence of the distal fibula directly over the approximate location of the nonunion.

location of the nonunion fragment of the distal fibula. With the lower extremity internally rotated, a #15 blade is used to make a 5-cm curvilinear incision in the skin overlying the fragment (Fig 2), and Metzenbaum scissors and blunt finger dissection are used to widen the incision. The lateral ankle capsule along with the ATFL is identified, and the ATFL is released proximally from its origin on the distal fibula fragment. The nonunion fragment is then removed from the fascial attachment with electrocautery and a Kocher (Fig 3), and fluoroscopic images are taken to confirm complete excision of the distal fibular nonunion fragment.

Anterior Talofibular Ligament Repair

A 2-0 fiber wire is passed through the detached ATFL and ankle capsule. The surgeon then applies tension on the suture, confirming that the suture is appropriately secured through the ligament. A drill guide is placed over the distal fibula, and a pin is used to drill a tunnel at a 20° angle in the posterior lateral aspect (Fig 4). The 2-0 fiber wire suture is loaded onto a 2.9-mm Arthrex PushLock suture anchor, and appropriate tension to the suture is applied while positioning the islet of the anchor over the drill hole. The ankle is placed in a neutral position prior to anchor insertion (Fig 5). Once the islet is advanced through the pilot hole aperture, a mallet is used to advance the anchor until the laser line is approximately flush with the bone (Fig 6). Once the anchor is placed into the distal fibula, the excess suture is cut to complete the repair. The integrity of the repair is inspected with direct palpation and a gentle range of motion stress on the ankle. A video detailing this operative technique is provided with this manuscript (Video 1).

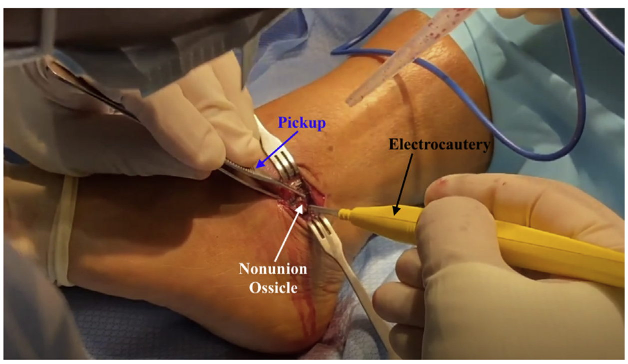

Fig 3. Nonunion fragment excision. The patient is positioned supine on the operating table with the left ankle internally rotated. The nonunion ossicle is identified and secured with a pickup. An electrocautery is used to release the fragment from its fascial attachment.

Postoperative Care

The capsule is closed with 0 Vicryl and the incision is closed with 2-0 Vicryl and 4-0 Monocryl. Dressing is applied. A posterior splint with a U-component is applied to the foot and secured with Ace wrap. To ensure proper rehabilitation, the patient is advised to be non-weight bearing and immobilized in the splint for the first 10 days after surgery.

At the first postoperative visit, the patient is instructed to be non-weight bearing and immobilized in an ankle boot until the 6-week mark. After the 6th week, the patient is advised to discontinue the use of ankle boot and start transitioning to weight bearing, as tolerated, and physical therapy, to regain full range of motion and strength. During the sequence of postoperative visits, radiographs of the ankle are taken in AP, lateral, and oblique views to monitor routine healing of the distal fibula (Fig 7).

Discussion

The surgical technique described in this article falls under the category of anatomical repair, as it allows surgeons to employ a single knotless anchor suture to attach the ATFL to its proper anatomical origin on the

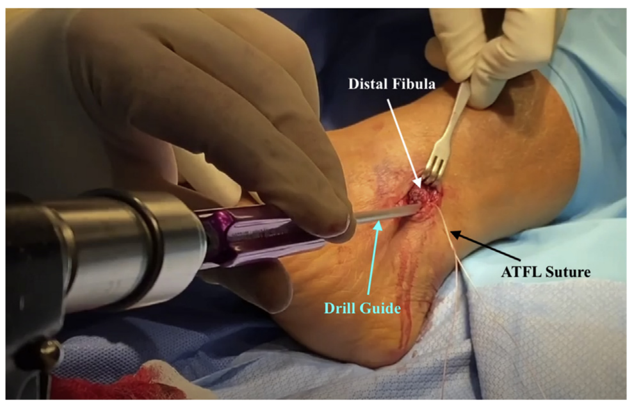

Fig 4. Drilling the tunnel for suture anchor. The patient is positioned supine with the left ankle internally rotated. A drill guide is positioned at a 20° angle in the posterior lateral aspect of the distal fibula. A pin passes through the drill guide (not shown) and is used to drill the tunnel for a 2.9-mm Arthrex PushLock suture anchor.

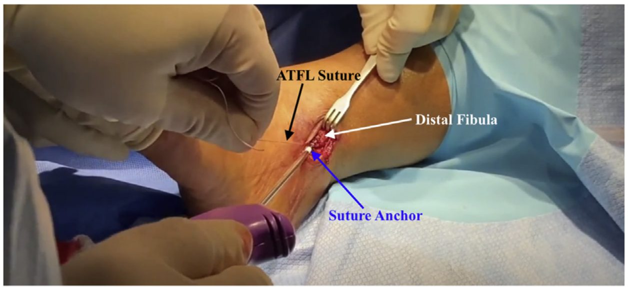

Fig 5. Preparation of suture anchor insertion. The patient is positioned supine on the operating table with the left ankle in a neutral position. The ATFL suture is loaded through the islet of the anchor. Appropriate tension is applied to the suture with the left hand to bring the ATFL in close proximity to the anchor. While exerting tension with the left hand, the islet is inserted into the left distal fibula using the right hand.

distal fibula. Various clinical studies have reported excellent outcomes from patients who underwent procedures that preserve ATFL anatomy.[12-16] In fact, the Broström technique, a standard procedure for ATFL anatomic reconstruction, consistently delivered 90%-95% good-to-excellent postoperative results in the long term.[17] Compared to the anatomic repair, the nonanatomic reconstruction also provides good to excellent stabilization of the ankle joint in 80–85% of patients.[18-20] However, because of the sacrifice of anatomic structures, patients who are treated with harvested tendon graft often report an increase in subtalar joint stiffness and impairment in eversion strength, which further increases the risk of developing secondary osteoarthritis in the ankle.[21-23] Previous research indicated that the Chrisman-Snook, a nonanatomic reconstruction, had a lower level of patient satisfaction than those treated with the modified Broström technique.[18] Since the procedure described in this article involves anatomic repair of ATFL, it has a lower risk for complications and morbidity associated with nonanatomic reconstructions, while successfully maintaining the subtalar joint motion and may have better patient satisfaction.

Our report describes the use of a single knotless suture anchor to repair the ATFL at the distal fibular location in an open manner after a distal fibular nonunion excision. We advocate for this simple and effective anatomical repair technique for the various advantages it has to offer. The utilization of a knotless suture anchor is unique from other ATFL repairs, including the traditional Broström procedure, which repairs the ATFL in the pants-over-vest fashion, and the modified Broström procedure which utilizes knot-requiring suture anchors. A controlled laboratory study demonstrated that knotless constructs diminish the inconsistency of knot tying, and, thereby, increase the reproducibility of the repair technique.[24,25] The use of knotless suture anchors produces comparable outcomes to knot constructs, while avoiding the potential issues with knot stacks, reducing operation time and technical difficulty and mitigating the risks related to prominent knot abrasions, such as cartilage damage and neuritis of the superficial peroneal or sural nerves.[26-30] Since knotless suture anchors may reduce postoperative complications and intra-articular irritation, it might also result in higher long-term satisfaction from patients. The technique also uses a single Arthrex Pushlock, which offers an easily achieved suture-locking mechanism that allows surgeons to accurately adjust tension under direct visualization. This feature presents a major advantage to the ATFL repair technique because producing proper tension is crucial for ensuring appropriate ankle stability and subtalar range of motion.

Additionally, the technique described in this article simplifies the ATFL repair by requiring only a single suture anchor at the distal fibula and avoiding the reinforcement of the inferior extensor retinaculum (IER). This, in turn, limits the number of drill holes and might help to reduce the risk of additional distal fibular fracture and bone loss. It also decreases the surgical equipment, steps, and time required for operation. The topic of IER reinforcement, introduced in the popular Broström-Gould technique, is controversial because of its technical difficulty and the longer operating time.[31,32] Tightening of the IER might also lead to reduced kinematics of the ankle joint since the calcaneal attachment is modified from the anatomical position.[29] Hence, there are various surgical cases in which surgeons decide to exclude the additional reinforcement or the IER. Among these simplified attempts is a repair introduced by Dr. Takao, using a single knot-requiring suture anchor to arthroscopically fix the ATFL to the distal end of the fibula, without additional IER reinforcement.[33]

Although there is concern regarding the strength of single knotless suture anchor repairs, a biomechanical study indicated an equivalent biomechanical strength

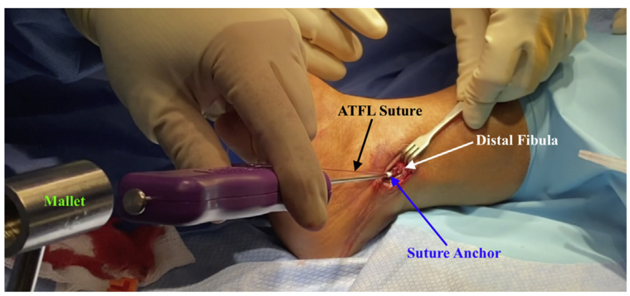

Fig 6. Insertion and advancement of the suture anchor. The patient is positioned supine with the left ankle in a neutral position. While the left hand continues to exert tension to the suture and stabilizes the suture anchor in position, the right hand uses the mallet to force the anchor to advance into the tunnel inside the left distal fibula.

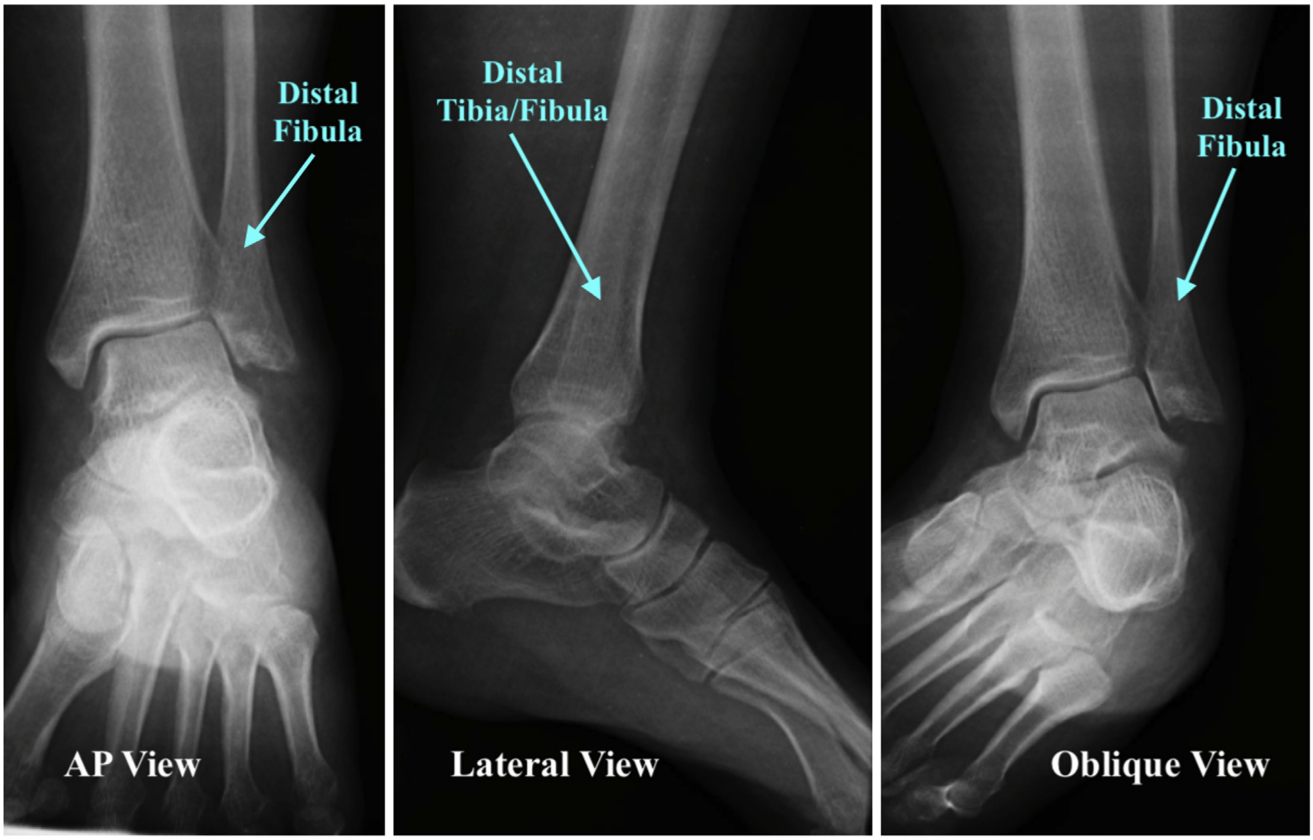

Fig 7. Postoperative radiograph images of the left ankle in the anterior-posterior (AP), lateral, and oblique views. In the AP and oblique view, the nonunion fragment below the distal fibula is absent, which indicates the successful removal of the nonunion. The lateral view indicated no osseous abnormality. The plastic suture anchor inside the distal fibula is not shown under radiographs.

between the knotless and knotted repair of ATFL injury.[34] Another biomechanical study reported that the single suture anchor repair at the distal fibular yields comparable strength and stiffness to that of the suture-only Broström repair.[35] In essence, the advantages of using a single knotless suture anchor outweigh any theoretical risks of this repair technique.

However, potential limitations of the technique must be addressed. First, the use of knotless sutures comes with the possibility of anchor pullout at the anchor-bone interface and the risk of suture breakage at the suture-tissue interface, as indicated in a biomechanical study.[36] With regard to the potential failure at the anchor-bone interface, there is a report of late disengagement of a knotless anchor, leading to articular cartilage damage.[37] There is also a potential risk of suture slipping out of the anchor, due to the mechanical challenge of keeping the high-strength sutures within a small suture anchor.[38,39] Second, there is a concern regarding the effectiveness of using a single suture anchor. A comparison study reported that double suture anchors of arthroscopic ATFL repair resulted in a superior functional outcome to that of the single suture anchor of arthroscopic ATFL repair.[40] Additionally, this technique carries a risk of peroneal tendon irritation caused by the suture anchor located at the posterior distal fibula area,[41] and a possibility of unintended peroneal tendon injury while creating a drill hole. Finally, an open ATFL surgery is associated with a 6% to 25% complication rate, including ankle pain and

Table 1. Advantages and Disadvantages of This Technique

Advantages
- Reduces surgical time and, thereby, shortens the time spent under anesthesia
- Decreases technical difficulties:
  - Only one suture anchor is required to provide a strong attachment to the distal fibula.
  - Knotless suture is simple and reproducible.
  - Exclude the reinforcement of the inferior extensor retinaculum.
- Allows surgeon to control the amount of tension under direct visualization
- Prevents the risk of chronic ankle instability

Disadvantages
- Concern about the compromised strength of a knotless anchor, considering the risk of anchor disengagement, suture breakage, and suture slippage.
- Single knotless anchor might have inferior functional outcome compared to double knotless anchors
- Risk of peroneal tendon irritation or peroneal tendon injury caused by suture anchor or bone drilling
- Complications associated with open ankle surgery

Table 2. Pearls and Pitfalls to Be Aware of When Completing an Anterior Talofibular Ligament Repair Using our Technique

Pearls
- Use fluoroscopic images to help approximate the location of the incision and to verify excision of distal fibula nonunion.
- While releasing the anterior talofibular ligament (ATFL) proximally, electrocauterize directly adjacent to the distal fibula, preserving the overall structure of the ligament.
- Confirm that an adequate amount of suture is placed through the ATFL with direct tension.
- Prior to insertion of the anchor into the drill tunnel, apply tension to the sutures to pull the ATFL towards the distal fibula.

Pitfalls
- Proper tensioning of the ATFL requires the ankle in a neutral position prior to anchor insertion, reducing the risk of ligament not healing properly over the distal fibula.
- Test the repair through gentle ankle inversion to confirm repair and test anchor purchase.

swelling.[42] A full list of the advantages and disadvantages of this technique is included in Table 1, and the pearls and pitfalls of this technique are listed in Table 2.

In summary, the ATFL repair described in this article offers a simple, rapid, and equipment-efficient surgical technique that restores the ATFL anatomy using a single knotless suture at the distal fibula without additional IER reinforcement. This results in a lower risk for complications related to the nonanatomic reconstruction of the lateral ankle and the use of prominent knots. The strength of this technique is also highlighted in the ability to create a strong and consistent fixation while being able to accurately adjust tension under direct visualization. Therefore, we recommend this technique for repairing ATFL following the removal of a distal fibular fragment.

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