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Repair of the Deltoid Ligament Using Posterior Tibial Tendon Autograft: A Novel Technique

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ABSTRACT

Posterior tibial tendon dysfunction (PTTD) is a progressive disorder secondary to advanced degeneration of the posterior tibial tendon, leading to the abduction of the forefoot, valgus rotation of the hindfoot, and collapse of the medial longitudinal arch. Eventually, the disease becomes so advanced that it begins to affect the deltoid ligament over time. This attenuation and eventual tear of the deltoid ligament leads to valgus deformity of the ankle. Surgical correction of PTTD is performed to protect the ankle joint at all costs. Generally, this is performed using osteotomies of the calcaneus and repair or augmentation of the deltoid ligament. Unfortunately, there has been no universal procedure adapted by foot and ankle surgeons for repair or augmentation of the deltoid ligament. Articles have discussed the use of suture and suture anchors, suture tape, nonanatomic allograft repair, nonanatomic autograft repair with plantaris, peroneal and extensor halluces longus tendons to repair and augment the deltoid ligament. There is very little literature, however, in regard to using the posterior tibial tendon to augment the deltoid ligament in accordance with hindfoot fusion for end-stage PTTD deformity. In general, the posterior tibial tendon in triple and medial double arthrodesis is generally removed because it is thought to be a pain generator. This article presents a case study and novel technique using the posterior tibial tendon to augment and repair the laxity of the deltoid ligament in an advanced flatfoot deformity.

Posterior tibial tendon dysfunction (PTTD) is classified as progressive failure of the posterior tibial tendon that causes pronation deformity of the hindfoot and collapse of the medial longitudinal arch. PTTD was originally classified into 3 stages describing progressive deformities about the foot.(1) Myerson later added a fourth stage describing valgus deformity of the ankle, which can be further classified into a flexible versus rigid deformity (2).

Valgus deformity of the ankle is the result of attenuation and disease of the deltoid ligament. The primary role of the deltoid ligament is to prevent valgus deformity and external rotation of the talus within the ankle joint (3). This role becomes compromised in late-stage PTTD because the posterior tibial tendon, which serves to protect the deltoid ligament, is no longer functional. The deltoid ligament is composed of 2 layers: superficial and deep. The deep component consists of the deep posterior and anterior tibiotalar ligaments. The superficial component consists of the tibiospring and tibionavicular ligaments. Of the 2 components, the deep deltoid provides the most stability against valgus deformity of the ankle (4,5). Cadaveric studies have shown that severed deltoid ligament components can lead to a decreased contact area of 43% and increased contact pressures of 30% (6).

Surgical treatment for stage 1-2 PTTD usually consists of periarticular tarsal osteotomies with tendon repair and tendon transfer. The rigidity and magnitude of stage 3-4 PTTD deformities require hindfoot arthrodesis to restore alignment. Along with hindfoot fusions, osteotomies and tendon balancing are often included as supplemental procedures to protect or correct valgus deformity within the ankle. These procedures have included peroneus brevis to longus tendon transfers, posterior calcaneal displacement osteotomy, and repair of the deltoid ligament (1–3,7–9).

There have been several procedures published concerning deltoid ligament repair; however, there is no general consensus on the model approach. Deltoid repair procedures have consisted of direct repair with suture and suture anchors, suture tape, nonanatomic allograft repair, nonanatomic autograft repair with plantaris, and peroneal and extensor halluces longus tendons, although these techniques have demonstrated various degrees of effectiveness. The results have been mixed, and surgeon contentment with these procedures has been highly differential (3,10–17,18).

This article presents a novel approach to deltoid ligament repair using the posterior tibial tendon to perform an anatomic repair to

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supplement hindfoot arthrodesis in late stage 3 and reducible stage 4 deformities. We present the surgical technique and 1 case study showing the potential benefit of this procedure technique.

Surgical Technique

The patient is placed on the operating table in the supine position and is anesthetized using general anesthetic. If required to maintain a rectus position of the foot on the table, a hip bump is placed under the ipsilateral hip and the leg is propped up on some form of elevated padding.

All ancillary procedures are performed before the elevation of the tourniquet. The authors perform a Strayer gastrocnemius recession, a peroneus brevis to peroneus longus tendon transfer, and bone marrow aspirate (BMA) harvest from the proximal tibia in standard fashion per previous literature. The thigh tourniquet is then raised to 350 mm Hg, and attention is directed to the medial hindfoot.

An incision is made just anterior to the distal tip of the medial malleolus and extends distally just past the navicular tuberosity (Fig. 1). Dissection is then carried down to the level of the posterior tibial tendon sheath via both blunt and sharp dissection (Fig. 2). The tendon sheath is then opened, and a tenolysis is performed with a Metzenbaum scissor. Generally, the diseased portion of the tendon generally lies within 2 to 3 cm of the insertion on the navicular tuberosity (Fig. 3). The tendon is then released from its insertion via sharp dissection, and the diseased distal portion is debrided to remove the bulbus portion and all local synovitis within the surrounding area. The tendon is dissected out proximally, and the distal portion of the tendon is tagged and saved for later use (Fig. 4).

Dissection is then carried out to expose both talonavicular and subtalar joints, respectively. Linear capsulotomies are performed through both joints; the ligamentous attachments around those joints are generally released to provide mobility for positioning and access for joint preparation. The joints are distracted with the use of self-retained or pin distractors to completely expose the joint surfaces for cartilage removal and preparation (Figs. 5 and 6). The authors choose to perform contour preparation of the fusion surfaces with the use of osteotomes, curettes, and a side cutter burr. The joint surfaces are then further prepped using both subchondral drilling and fish scaling techniques. The joints are finally further augmented with the use of allograft/BMA mixture in combination with some form of either demineralized bone matrix or stem cell substitute (Figs. 7 and 8).

Fig. 1. Incision placement.

Fig. 2. Dissection showing the posterior tibial tendon sheath.

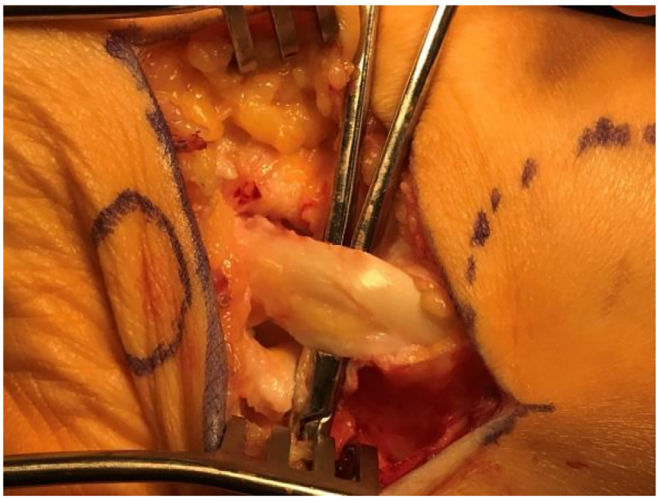

Fig. 3. Posterior tibial tendon showing distal tendon disease.

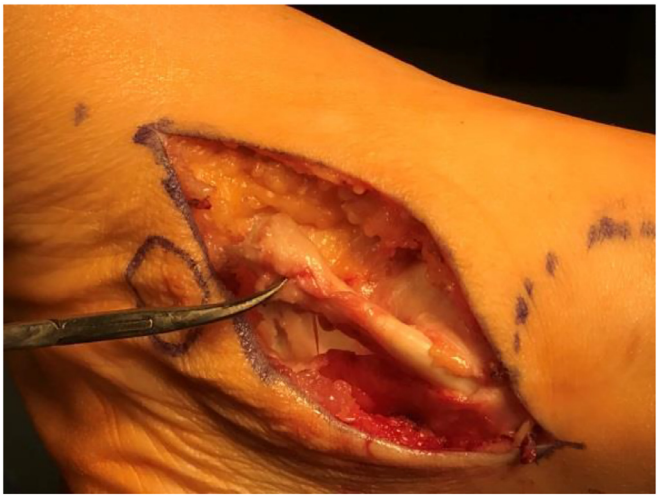

Fig. 4. Dissected posterior tibial tendon.

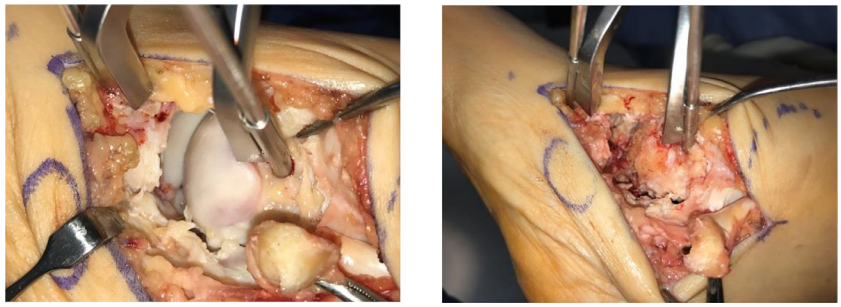

Fig. 5. Talonavicular joint before and after arthrodesis preparation.

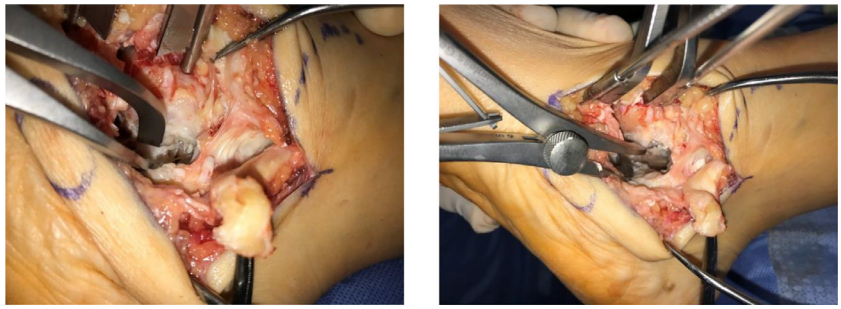

Fig. 6. Subtalar before and after arthrodesis preparation.

Fig. 7. Allograft material with bone marrow aspirate mixture.

The hindfoot is then placed in proper position manually using the windlass mechanism/Hubscher maneuver, along with supination of the hindfoot. Adequate positioning is confirmed via image intensification. The authors generally first provisionally fixate the talonavicular joint using guide wires for cannulated screw fixation. The subtalar is then generally fixated using 2 large-diameter (≥6.5 mm), partially threaded cannulated compression screws. An anterior pillar screw is sometimes used to further stabilize the subtalar joint. The talonavicular joint is then fixated using either 3 partially threaded cannulated compression screws (≥4.0 mm) across the medial, central, and lateral portion of the joint or a combination of 2 screws and a small locking plate.

Attention is then directed toward the ankle joint, in which both medial and lateral stress radiographs are performed of the ankle. If the lateral ankle stress radiographs reveal laxity, a Brostrom-Gould procedure is performed. If the medial stress view shows valgus tilt, the authors stabilize the deltoid ligament.

Using an Allis clamp, the posterior tibial tendon is pulled out past the medial malleolus with as much tension on the tendon as possible. The tendon is then marked at the level in which the tendon passes the distal tip of the medial malleolus. A suture anchor is inserted into the distal tip of the medial malleolus, and the tendon is sewn into the

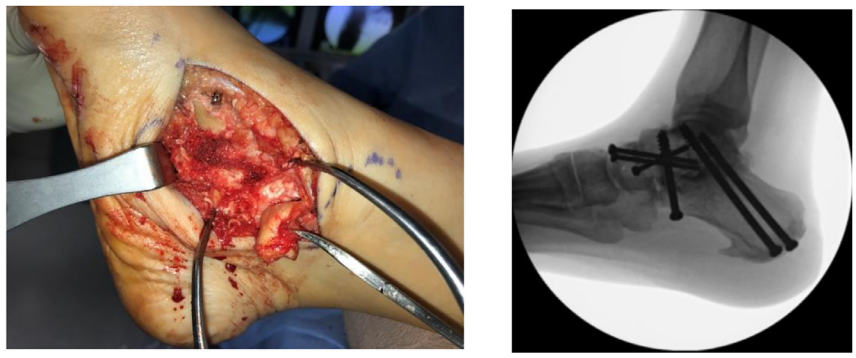

Fig. 8. Talonavicular and subtalar joints with augmentation with graft and stem cell augmentation after fixation.

Fig. 9. Posterior tibial tendon transfer to medial malleolus.

medial malleolus at the level at which the tendon was marked previously (Fig. 9).

The remaining distal tendon is then hemisected, leaving approximately 1 cm of tendon intact distal to the previous new insertion on the medial malleolus (Fig. 10). The dorsal portion of the tendon is carried to the medial neck of the talus, and the inferior portion is carried beneath the flexor retinaculum and tendon sheath to the sustentaculum tali of the calcaneus (Figs. 11 and 12). The tendon sections are fixated under tension to the medial neck of the talus and sustentaculum tali of the calcaneus in the same fashion as the medial malleolus using individual suture anchors for each hemisection to those respectable anatomic landmarks, as shown in Figs. 11 and 12. This technique allows the surgeon to mechanically control tension applied without providing too much tension on the deltoid repair. The incision site is then flushed, and standard layered closure is performed.

The patient is placed in a posterior splint or short leg cast postoperatively. The patient remains non-weightbearing in a short leg cast for approximately 6 to 8 weeks to allow the arthrodesis sites to consolidate. The patient is then transitioned to weightbearing in a fracture walking boot. After 2 to 4 weeks of protective weightbearing, the patient is transitioned into a tennis shoe and is allowed gradual return to normal daily activities. The patient is provided with physical therapy as needed.

Case Study

This case study presents a 39-year-old male who presented to us with chronic right foot pain. On evaluation clinically and radiographically, the patient was diagnosed with stage 3 PTTD per the Johnson and Strom classification. Previously, the patient presented with similar symptoms to his left foot in which he underwent a flatfoot reconstruction consisting of hindfoot arthrodesis along with other adjunctive procedures. It was determined the patient would benefit from a similar reconstructive surgery to the right foot.

The patient presented to the hospital and underwent a medial double hindfoot arthrodesis with ancillary procedures, including gastrocnemius recession, peroneus brevis to peroneus longus tendon transfer, and BMA harvest. At the completion of the case, the patient had both medial and lateral stress radiographs performed to evaluate the stability of the ankle joint. The medial stress view revealed increased medial clear space and deltoid insufficiency.

The deltoid ligament was present and appeared intact after the case without any signs of disease or extensive inflammation (Fig. 13); however, with the stress findings being positive, a decision was made to proceed with deltoid ligament reconstruction. A deltoid repair using the posterior tibial tendon was performed to augment the stability of the deltoid ligament. A repeat medial stress test was performed under

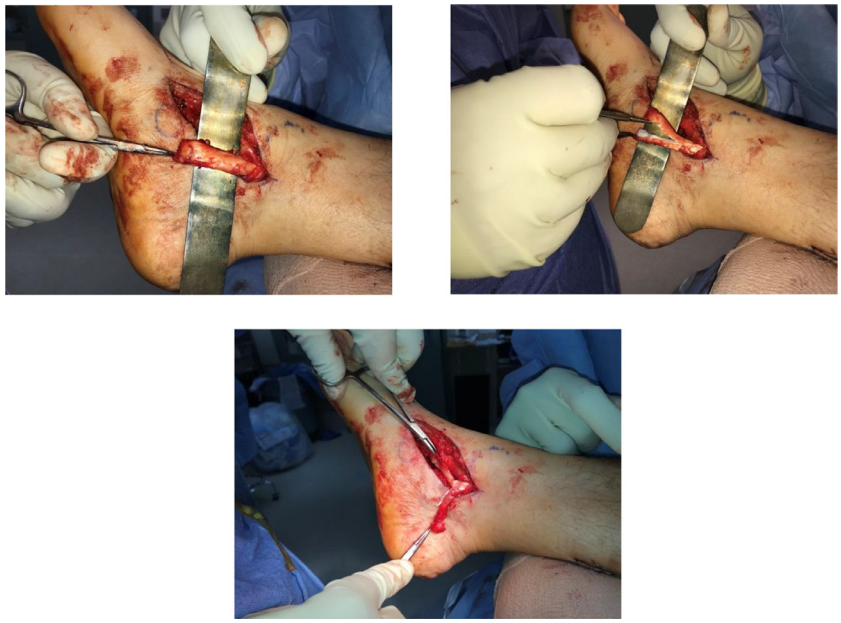

Fig. 10. Hemisecting of posterior tibial tendon.

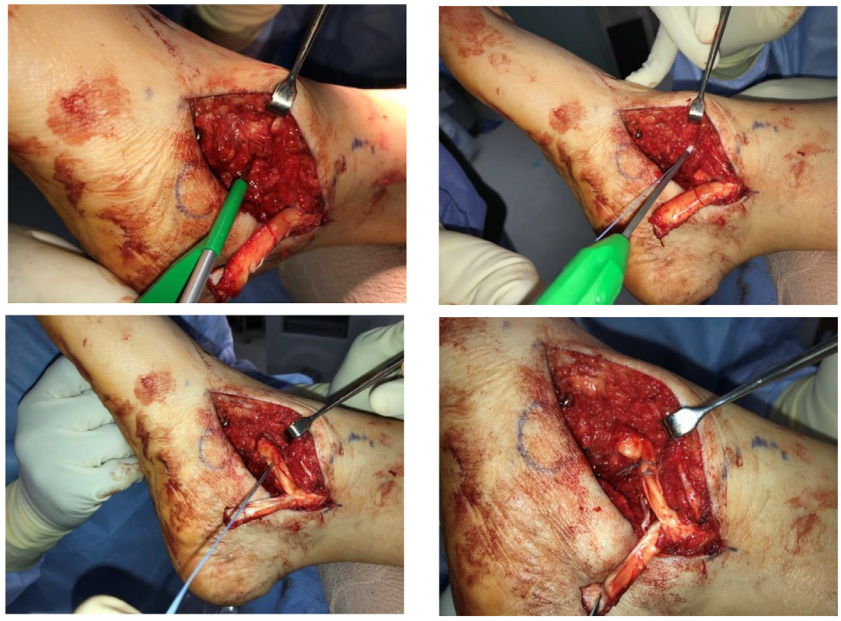

Fig. 11. Talar posterior tibial tendon fixation.

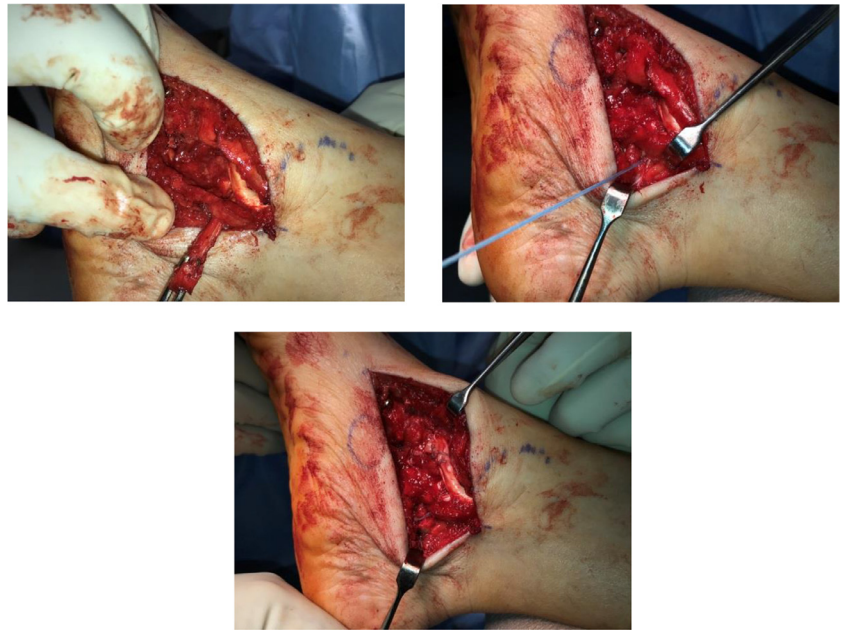

Fig. 12. Calcaneal sustentaculum tali posterior tibial tendon fixation.

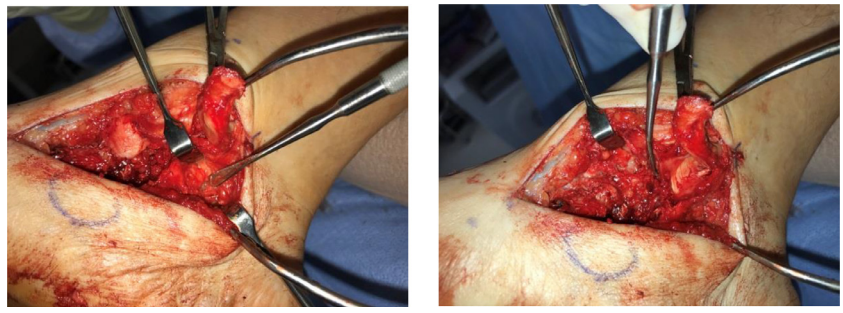

Fig. 13. Intact deltoid ligament.

fluoroscopy following deltoid ligament augmentation, which showed a congruent ankle joint.

The patient was admitted for 23 hours of observation after the procedure and was then discharged to follow our standard postoperative protocol. The patient has returned to normal daily activities with minimal pain and no complaints of ankle instability, and has progressed well over the 14-month duration of follow up.

Discussion

Several procedures have been developed and recommended for deltoid ligament repair; however, there is no general consensus on the ideal technique. Previous deltoid repair procedures have consisted of direct repair with suture and suture anchors, suture tape, nonanatomic allograft repair, nonanatomic autograft repair with plantaris, peroneal and extensor halluces longus tendons. With these techniques, each form of repair proposes some challenges in terms of healing and long-term effects on function and mechanics of the foot and ankle. Bluman and Myerson (2) described the importance of strong healthy tissue to reconstruct both the deep and superficial components of the deltoid ligament (18).

The most commonly used techniques have been described by Deland et al (16) and Bluman and Myerson (2), in which the authors use peroneus longus and forked hamstring allograft, respectively (17). The use of peroneus brevis autograft by Deland et al (16) autograft showed an average talar tilt correction from 10° preoperatively to 3.6° postoperatively with a minimum 2-year follow-up. One patient was considered a failure with a residual 9° of talar tilt postoperatively (16). Ellis et al (17) published a continuation study showing that after a mean 8.9 years of follow-up, there was a mean postoperative talar tilt of 2°. A drawback of the procedure by Deland et al (16) is that the reconstruction involves repair of the deep deltoid component only, as well as donor site morbidity. Bluman and Myerson (2) described their technique with a forked hamstring allograft for reconstruction of both the superficial and deep deltoid complex.

Autograft repairs, similar to our work, propose issues with donor site morbidity (17). Ellis et al (17) initially showed great results with peroneus longus tendon transfer for deltoid repair; however, they found that donor site morbidity and biomechanical balancing of the foot is affected by tendon transfer. There is an argument that autograft tissue is stronger and leads to a stronger and more durable repair. To achieve similar strength of correction, larger allografts must be used to theoretically achieve the same strength. Allografts have risks associated with rejection, attenuation, and infection (17). Some surgeons performing stage 3 PTTD surgery often evacuate the posterior tibial tendon. This allows greater access to the subtalar joint for preparation and eliminates what is considered to be a pain generator. The authors' technique uses relatively healthy connective tissue; uses the healthy portion of a diseased tendon, which no longer has functional requirements following hindfoot arthrodesis; eliminates the morbidity associated with harvest of autogenous tendons; and avoids the disadvantages associated with tendon allograft transplant. Our procedure also addresses both superficial and deep components of the deltoid ligament, leading to a stronger overall construct while using the patient's own tissue.

Deltoid repair with suture anchors and direct ligament repair has also been reported with good outcomes; however, the literature reviewing this repair technique evaluates the repair in the setting of traumatic injury of the deltoid. Although it can be assumed that the results would be similar in the flatfoot population, it does not account for attenuation of the deltoid ligament but only partial or complete tears (19).

FiberTape has also been described as an option for deltoid repair (3). Literature has shown that lateral ankle ligament repairs with FiberTape augmentation show superior strength and resistance to deformity (20); however, similar results have yet to be shown with deltoid ligament repair.

Our procedure was shown to be immediately effective, with both radiographic stress testing and follow-up revealing clinical stability of the ankle joint against medial stress. This technique provides excellent stability using host tissue without the need for sacrificing host tendon and function to repair the deltoid ligament. In addition, our approach allows for anatomic repair of the deltoid ligament, providing increased stability of both deep and superficial fibers of the deltoid ligament.

In conclusion, a long-term follow-up with multiple patients would be ideal to further evaluate this technique for durability and predictability. This technique will likely evolve over time to include the use of a blind tunnel technique and biotenodesis fixation, which would allow for more control of the tension of the repair and add to the stability of the repair, leading to potentially better long-term results.

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