



Anterior Tibial Tendon Side-to-Side Tenorrhaphy after Posterior Tibial Tendon Transfer: A Technique to Improve Reliability in Drop Foot after Common Peroneal Nerve Injury

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Abstract: Common peroneal nerve injury is present in 40% of knee dislocations, and foot drop is the principal complication. Posterior tibial tendon transfer is a viable solution to replace the function of the anterior tibial tendon (ATT) in the mid-foot. Several techniques for posterior tibial tendon transfer exist today, with variable results reported. However, adding augmentation with side-to-side tenorrhaphy of ATT to the transferred posterior tibial tendon (PTT) enhances anterior tissue balance and load sharing stress between native ATT entheses and PTT tenodesis, allowing early rehabilitation and improving functional outcomes. Side-to-side tenorrhaphy is performed after PTT tenodesis in the lateral cuneiform to improve reliability in foot drop. This technique allows shorter immobilization time (from 6 to 2 weeks), earlier rehabilitation, sooner weight-bearing, and decreased risk of arthrofibrosis, scar formation, and muscle atrophy.

Common peroneal nerve (CPN) injury frequently is associated with multiligament knee injuries with an incidence of 10% to 40% of the total knee dislocations.¹⁻⁵ Early diagnosis is crucial since nerve recovery is rare when there is a complete injury.⁶⁻⁸ The main consequence after CPN injury is foot drop with functional impairment while walking, with the patient developing a steppage gait.⁹⁻¹¹

To reduce ankle immobilization time and to improve the reliability of posterior tibial tendon transfer (PT-TT), we propose a transfer tendon augmentation technique

making a side-to-side tenorrhaphy from the anterior tibial tendon (ATT) to the tenodesis of the posterior tibial tendon (PTT). In this procedure, the native ATT is sutured to the PTT using a pulley suture technique. In a biomechanical study, Wagner et al.¹² demonstrated that a pulley running locked or simple 8 suture in side-to-side tenorrhaphy provides assurance to the surgeon who advocates immediate loading or motions at the repair site.

This article describes an augmentation technique for the posterior tibial tendon transfer by using side-to-side ATT tenorrhaphy that permits starting earlier rehabilitation and decreases complications resulting from long immobilization periods.

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Surgical Technique (With Video Illustration)

Patient Positioning

The patient is placed in supine position after epidural anesthesia. A well-padded tourniquet is set in the thigh and the operative leg is prepared and draped in standard fashion.

Anatomic Landmarks

Four surgical incisions are used in this technique. To establish them, it is important to identify and draw some



Fig 1. Supine position, right foot, medial view. (A) The first incision is made distal to the medial malleolus at the medial border of the navicular bone. (B) The second incision is made from 10 cm proximal to the tip of the medial malleolus. (C) Final view of the 2 first incisions. (MM, medial malleolus.)

important landmarks, that is, the medial malleolus, the posteromedial border of the distal tibia, and navicular and medial cuneiform (Video 1).

Surgical Incisions

The first incision is 3 cm long and is made distal to the medial malleolus at the navicular medial border (Fig 1

A and C). The second approach is a 3-cm longitudinal incision parallel and next to posteromedial border of the distal tibia, starting 10 cm from the tip of the medial malleolus in the proximal direction (Fig 1 B and C). The third incision is approximately 3 cm long and is marked lateral to the anterior border of the distal tibia, parallel to the second incision (Fig 2A). Finally, the fourth

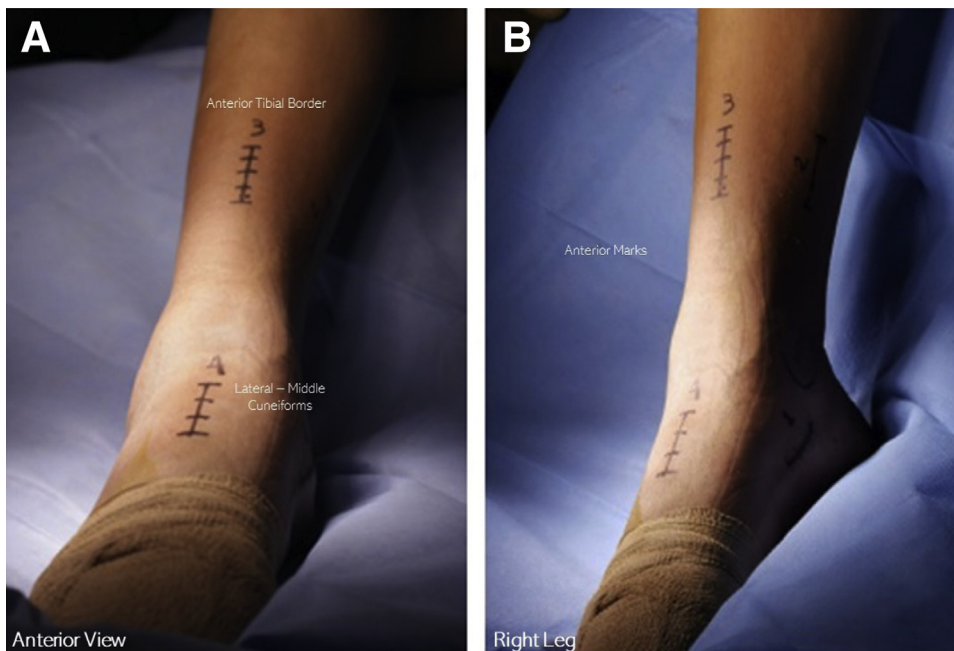


Fig 2. Supine position, right foot, anterior view. (A) The third incision is made parallel to the second incision at the anterior border of the tibia and the fourth incision is over the lateral and middle cuneiforms. (B) Final view of the anterior marks.

approach is 4 cm long, located proximally from the metatarsal-cuneiform joint, above of lateral cuneiform (Fig 2B, Table 1).

Posterior Tibial Tendon Harvest

Through the first incision, the insertion of the posterior tibial tendon is identified at the level of the navicular bone (Fig 3A). The second incision is used to identify and separate the PTT from the longus flexor digitorum tendon. At this step, it is essential to identify the saphenous nerve and vein medial to the posterior fascia, to avoid injuries (Fig 3B). The nerve and vein are pulled anteriorly while the fascia is opened to have access to the posterior compartment of the leg. The longus flexor digitorum tendon is located more medial and needs to be displaced posteriorly to visualize the posterior tibial tendon (Fig 3C).

Once the PTT is identified, an angled clamp is used to pull it through the incision to ensure that when it is under stress the foot is moved in dorsal flexion, adduction, and supination. With this maneuver, we can be sure that the proximal grasped tendon is the posterior tibial (Fig 3D). We proceed to perform PTT tenotomy through the first incision from its insertion at the navicular bone. In this step, it is important to harvest the tendon as long as possible; otherwise, a short tendon can limit the tenodesis to a nearest point, decreasing the lever arm of the transferred tendon. After the tenotomy the PTT should be released from the surrounding structures, then it can be pulled from the second incision to expose the entire tendon (Fig 4A).

Posterior Tibial Tendon Preparation

The last 3 cm of the tendon is divided with a scalpel into 2 branches (Fig 4B). Every limb is prepared with Krackow stitches using a high-strength orthopaedic partially resorbable suture (ORTHOCORD #0; DePuy Mitek, Inc., Raynham, MA) that later will be used to pull the tendon through the interosseous membrane (Fig 4C).

Posterior Tibial Tendon Transfer

In the third incision, the interosseous membrane is identified in the anterior compartment of the leg. A longitudinal window of 5 cm is performed in the interosseous membrane to transfer anteriorly the posterior tibial tendon. In this step, it is important to avoid trapping or pulling any neurovascular structure. The posterior tibial tendon goes through the window of the interosseous membrane (Fig 4C), and under the flexor retinaculum a path is performed using a long-angled clamp to pull the PTT from the third incision. This clamp is placed under the retinaculum from the fourth incision and crosses it to get out through to the third approach to catch the suture limbs and pull them to the tenodesis site at the middle and lateral cuneiforms (Fig 5).

Posterior Tibial Tendon Tenodesis

The fourth incision is made over the medial cuneiform. The posterior tibial tendon tenodesis can be done with bone tunnel invagination or anchor fixation (Fig 6 A and B). In cases in which the harvested tendon is short, we prefer to fix it using 2 PEEK (polyether ether ketone) knotless anchors (HEALIX ADVANCE 4.75 Knotless Anchor, DePuy Mitek, Inc.), one placed in the medial cuneiform and the second one in the lateral cuneiform to permit a strong and balanced lever arm (Fig 7). If the harvested tendon has enough length, the tenodesis can be performed using transosseous tunnels invaginating every stump into the tunnels aiming for tissue scar formation. A 4.5-mm V-shaped tunnel is drilled in the lateral cuneiform, allowing to connect both bone tunnels in the vertex. Then, with the use of a passer suture (CHIA PERCPASSER Suture Passer; DePuy Mitek, Inc.), each tendon limb is passed through the tunnel and caught in the contralateral hole. Then, every suture limb is pulled out in the opposite direction to achieve limb tendon invagination, the foot is held in neutral position, and sutures are tied with simple squad knots to keep the tension of the posterior tibial tendon (Fig 6A).

Table 1. Anatomic References and Incisions for the PT-TT Plus Side-To-Side ATT Tenorrhaphy

Incision	Size, mm	Anatomic Landmarks	Procedure
1	30	Distal to the tibial malleolus	PTT tenotomy
2	30	Posteromedial tibial border 10 cm from the medial malleolus tip	PTT identification and grafting PTT preparation
3	30	Anterior tibial border 10 cm from the medial malleolus	Interosseous membrane window Anterior transfer to the PTT
4	40	Medial and lateral cuneiforms	Pass under the flexor retinaculum PTT tenodesis to the cuneiforms ATT tenorrhaphy to the transferred PTT

NOTE. Four surgical incisions are used in this technique. It is important to identify and draw the landmarks: medial malleolus, the posteromedial border of the distal tibia, navicular, and medial cuneiform.

ATT, anterior tibial tendon; PTT, posterior tibial tendon; PT-TT, posterior tibial tendon transfer.

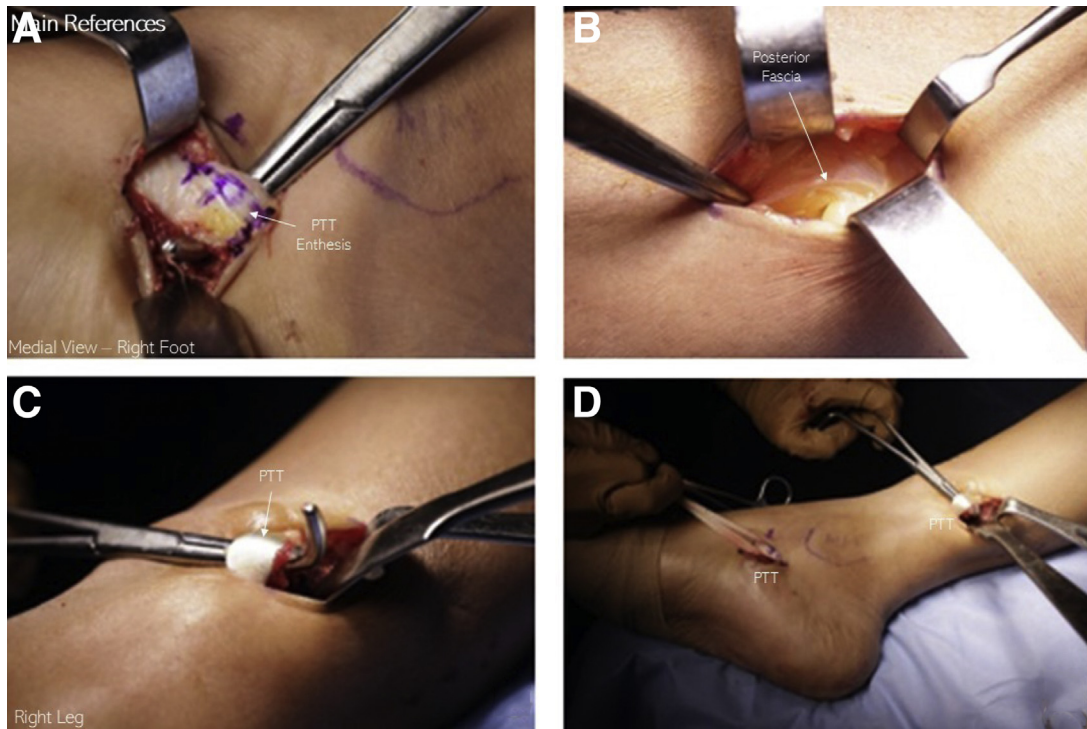


Fig 3. Supine position, right foot and leg, medial and anterior view. Main references for tendon identification. (A) Through the first incision the PTT entheses is identified. (B) In the second incision, under the subcutaneous tissue the saphenous nerve is identified and pulled laterally to get access to the posterior fascia. (C) In the deep posterior compartment, the PTT is identified and pulled. (D) The PTT is pulled through the first and second incisions to be sure before cutting it. (PTT, posterior tibial tendon.)

Anterior and Posterior Tibial Tendon Side-to-Side Tenorrhaphy

The final step of this technique is to attach the native anterior tibial tendon to the transferred PTT at the level of the fixation site. The ATT entheses is identified, and

the last 2 cm are pulled in proximal direction and sutured in a side-to-side technique with a high-strength orthopaedic partially resorbable suture (ORTHOCORD #0; DePuy Mitek, Inc.) to the transferred PTT (Fig 8). The objective of this augmentation is to provide tension

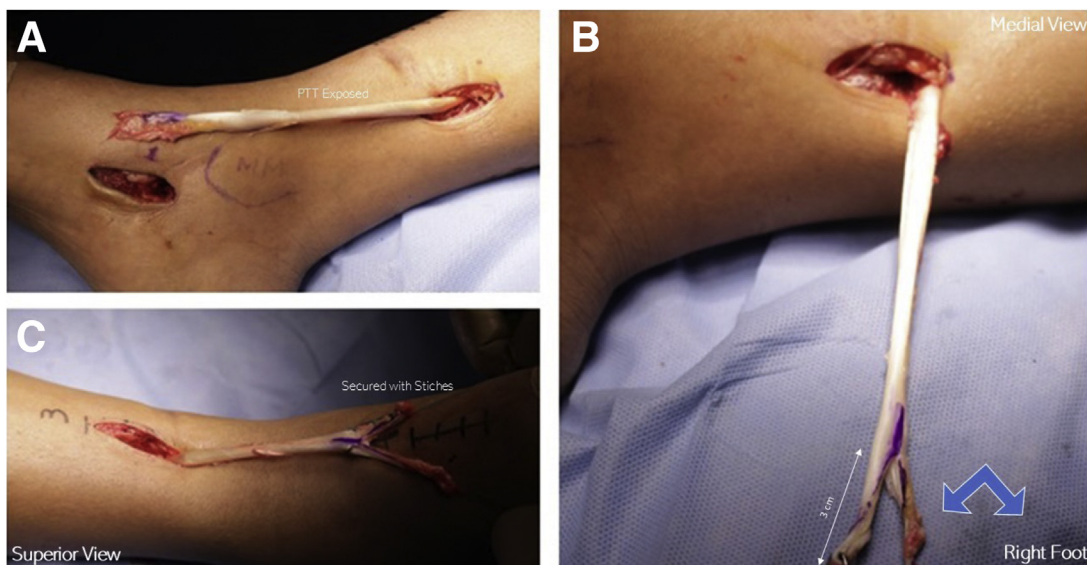


Fig 4. Supine position, right foot, medial and superior view. Tendon exposure and preparation. (A) The PTT is pulled and fully exposed. (B) The last 3 cm is divided into 2 branches. (C) The 2 branches are secured with a Krakow stitches to pull them at the tenodesis step. (PTT, posterior tibial tendon.)

Fig 5. Supine position, right foot, superior view. Before the bone fixation the tendon is passed under the flexor retinaculum and exposed by pulling it through the fourth incision. (PTT, posterior tibial tendon.)



to the lax and nonfunctional ATT, increasing the strength and balance of the transferred tendon (Fig 6C).

Postoperative Care

A short walker boot is left on for 2 weeks to keep the ankle in neutral position and permit the tendon integration to the bone. At week 2, the patient starts with passive movements of foot dorsiflexion assisted with a bandage and active plantar flexion. Partial weight-bearing is allowed at week 2, whereas total weight-bearing is permitted at the fourth week. Muscle strength therapy of foot and ankle is started at the third month and monitored with isokinetic testing. When the

operated limb reaches at least 90% of muscle strength compared with the nonoperated limb, sports activities are permitted.

Discussion

The main goal of side-to-side tenorrhaphy is to permit earlier progress to a walking reeducation phase. The international post-tenorrhaphy guidelines advocate early active mobilization of tendon repairs, thereby increasing the need to achieve a mechanical strong repair.¹³ The STS-T proposes a stronger reconstruction model that permits sharing pull force strength and soft-tissue balance, which allows an earlier joint motion and

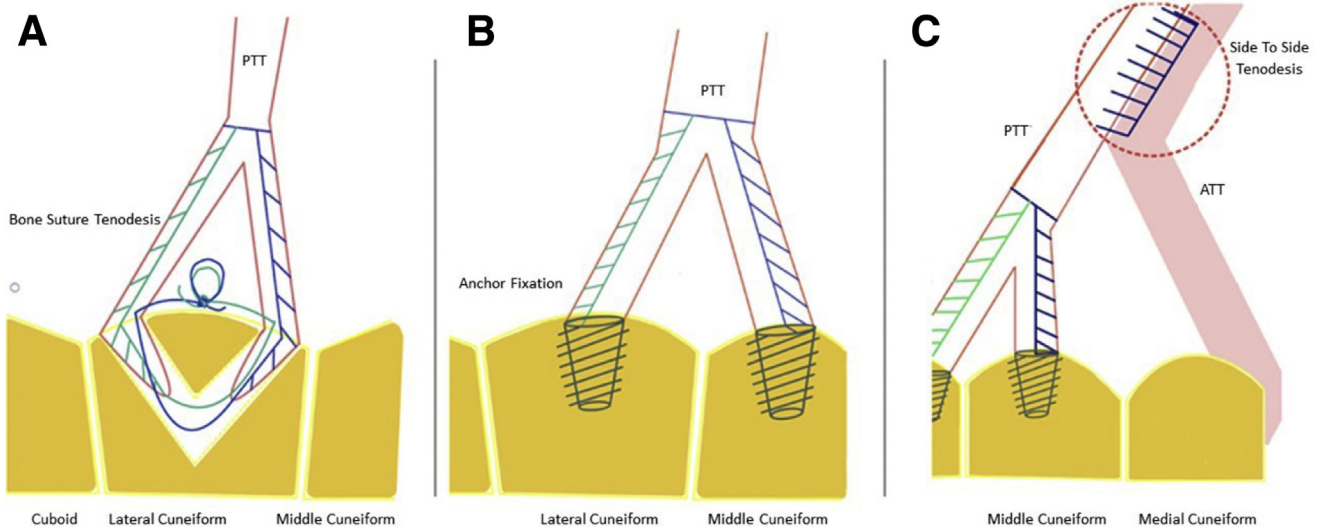


Fig 6. Scheme of the different tenodesis techniques. (A) Transosseous tenodesis using the “V shape” double-tunnel technique on the lateral cuneiform. (B) Tenodesis with anchor technique in 2 different cuneiforms. (C) Side-to-side tenodesis technique illustration (The ATT enthesis position represented is just for illustrative purposes). (ATT, anterior tibial tendon; PTT, posterior tibial tendon.)

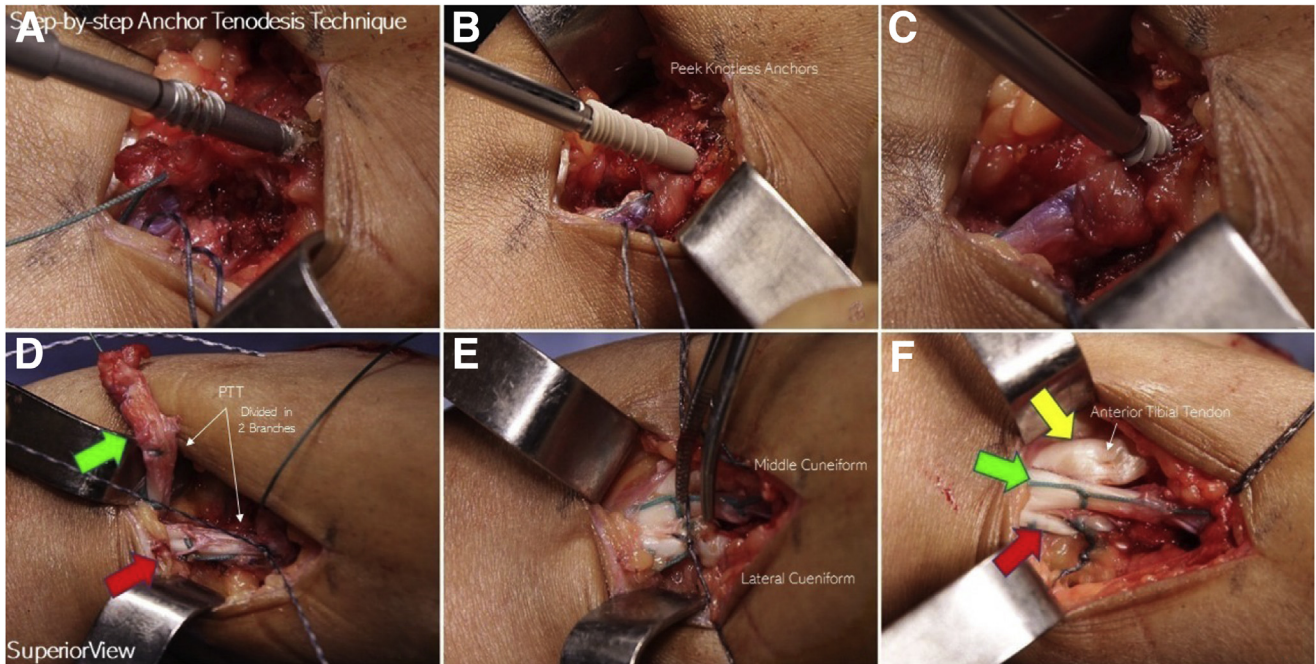


Fig 7. Supine position, right foot, fourth incision close up. Anchor tenodesis technique. (A-F) Step by step of the anchor tenodesis technique using 2 PEEK knotless anchors (HEALIX ADVANCE 4.75 Knotless Anchor; DePuy Mitek, Inc., Raynham MA, USA).

better muscle performance.^{14,15} Some studies propose the use of a long-time lower-leg splint (or combined with a cast) up to 6-8 weeks after tendon transfer.^{16,17} This delay in the rehabilitation process increases muscle weakness and arthrofibrosis risk because of prolonged immobilization. Furthermore, from the eighth week, the patient has to continue with assisted gait using a walker until the twelfth week.¹ The side-to-side tenorrhaphy acts sharing loads to the native ATT entheses and PTT tenodesis, permitting one to start much earlier

with ankle motion and re-education phase, avoiding muscle atrophy from a long period of casting.¹⁸ Moreover, early mobilization promotes better joint motion, limits adhesion formation, and improves rehabilitation outcomes. An early postoperative rehabilitation program prevents muscle atrophy, allows better healing and more physiologic collagen remodeling, and yields better overall function.^{12,13,19}

To pull only the anterior tibial tendon would cause a valgus deformity because lateral peroneal tendons are

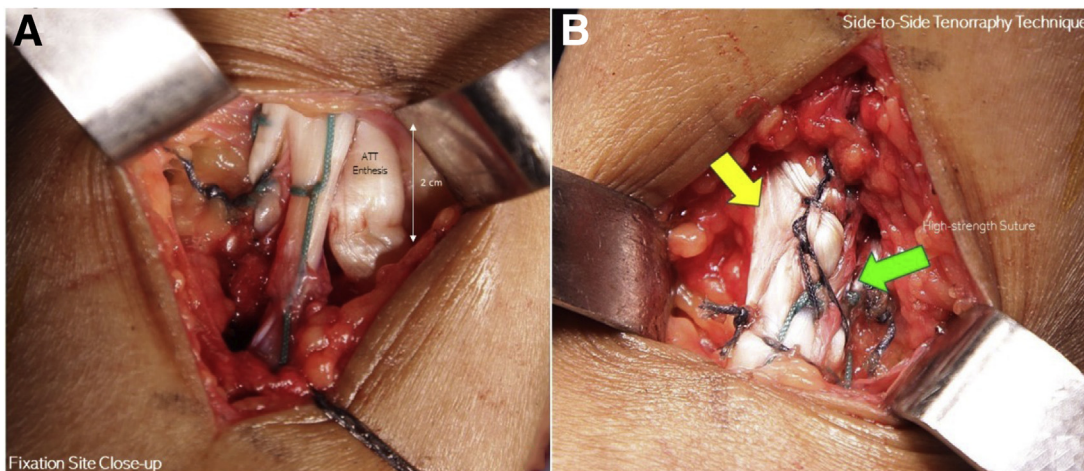


Fig 8. Supine position, right foot, fourth incision close up. Side-to-side tenorrhaphy technique. (A) The ATT entheses is identified. (B) The last 2 cm are pulled into proximal direction and sutured in a side-to-side manner with high-strength orthopaedic partially resorbable suture (ORTHOCORD #0; DePuy Mitek, Inc.) to the transferred PTT. (ATT, anterior tibial tendon; PTT, posterior tibial tendon.)

Table 2. Advantages and Limitations of Anterior Tibial Tendon Side-to-Side Tenorrhaphy

Advantages	Limitations	Risks
Earlier rehabilitation	Limited excursion of PTT (2 cm)	Interosseous adhesions (narrow window)
Balance between the medial and lateral foot with the use of 2 branches of PTT	Adjustment of the tendon in bone tunnel fixation	Vessel injury
Stronger lever arm	Suture loose tension in time with bone tunnel fixation	Neuropathic arthropathy (fixation in tarsal tunnel)
Osseus tunnel fixation		Bone tunnel fracture
Voluntary active dorsiflexion		Rupture of PTT when split into 2 limbs
Restore normal heel-toe gait		
Best kinematics		
Prevents foot inversion		
Avoid the cast-related complications		

NOTE. Important concepts to consider for this surgical technique. It is important to assess every case individually to achieve better results. PTT, posterior tibial tendon.

affected due to its innervation with the CPN. Pulling forces must be balanced by applying central traction forces to the lateral cuboid bone. Thereby, surgeons can achieve a balanced flexion force.^{20,21} The tenodesis on the medial cuneiform permit a central pull flexion force and the STS-T add a stronger construct, moreover, adding a second and balanced pull force. Biomechanical studies show that STS-T should be able to withstand the physiologic demands from earlier phases.^{12,21-23} These results improve reliability after PTT-T with STS-T augmentation, allowing us to increase the physical demand from the early postoperative period avoiding complications related to leg immobilization and non-weight-bearing. Advantages, risks, and limitations of anterior tibial tendon side-to-side tenorrhaphy are discussed in [Table 2](#).

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