Review Article

Management of Anterior Tibialis Tendon Ruptures

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ASSOCIATED VIDEO

ABSTRACT

Anterior tibialis tendon ruptures, while relatively infrequent ruptures, are commonly identified in delayed fashion, which can lead to significant impairments in patient gait and function. Surgical treatment is typically required to restore ankle dorsiflexion function and proper gait. Depending on various patient-specific factors, tendon quality and excursion, and chronicity, a range of treatment options are available to manage these patients, from nonsurgical care to surgical treatment. Surgical options include direct repair, local tendon transfer, autograft tendon reconstruction, and allograft tendon reconstruction. Additional procedures may need to be considered. Despite the variety of described surgical procedures, limited evidence-based guidelines are available to direct surgeons in the most optimal treatment for their patients. In addition to the relevant anatomy, biomechanics, and pathoanatomy, the reconstructive armamentarium is detailed and reviewed here, along with outcomes and potential complications, to guide surgeons in the most appropriate treatment for their patients.

First described by Dr. Brüning in 1905, rupture of the anterior tibialis (AT) tendon is a rare rupture with several hundred cases reported in the literature.[1,2] Despite the rarity, these ruptures still represent the third most common lower extremity tendon rupture in the human body, and is one of the most common silent tendon ruptures in patients older than 70 years.[3] The primary function of the AT tendon is to dorsiflex and invert the ankle. An untreated rupture can lead to gait impairment and progressive deformity, including loss of the medial longitudinal arch, equinus contracture, and lesser toe contractures.

Traumatic injuries typically result from a direct laceration to the tendon (eg, a knife or a sharp bone fragment from a distal tibial or talus fracture) or a forcible plantar flexion moment applied to an eccentrically contracting AT muscle.[4-6] Atraumatic ruptures can have a variety of causes. Poor vascularity, underlying tendinopathy, and medical comorbidities (eg, diabetes mellitus, gout, systemic lupus erythematosus, conditions requiring long-term corticosteroid use, renal dysfunction, and inflammatory arthropathy) can contribute to attritional rupture. Local corticosteroid injections (eg, medial midfoot or ankle joint injections) and fluoroquinolone use may contribute to tendon degeneration.[7-12] Anterior ankle or dorsomedial midfoot osteophytes can impinge and produce an attritional rupture (Figure 1).

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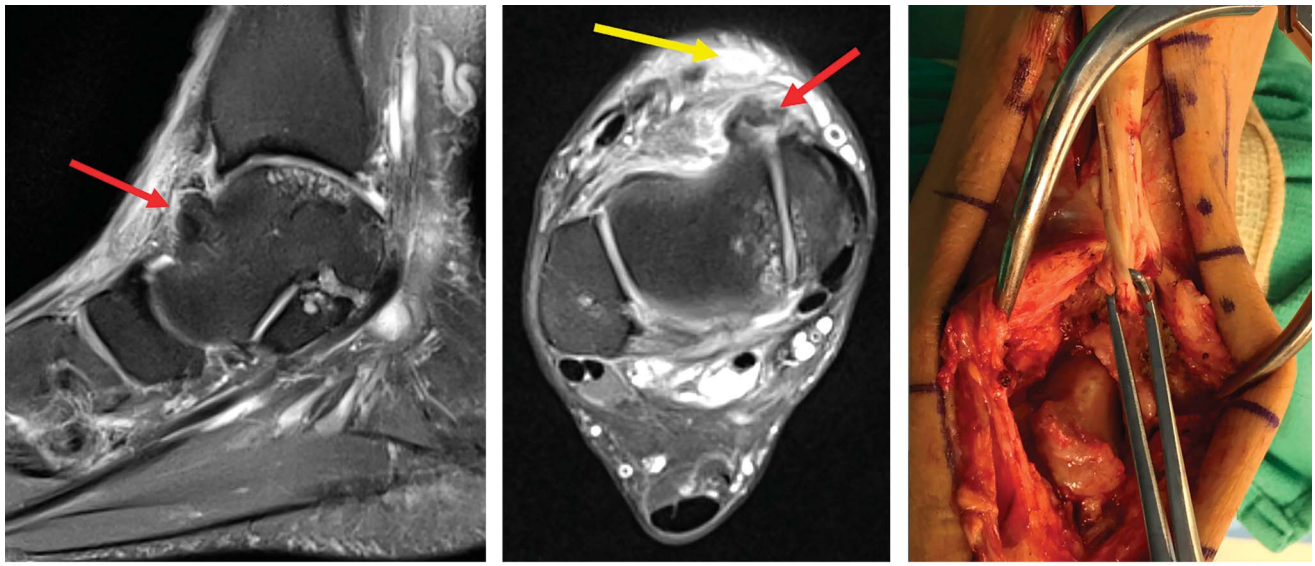
Figure 1



Sagittal (**A**) and axial (**B**) Proton density MRI sequences demonstrating an AT tendon attritional rupture with retracted tendon stump, due to impinging, anteromedial ankle osteophytes (**A** and **B**, red arrow). An empty tendon sheath sign (**B**, yellow arrow) is seen near the anteromedial ankle. Intraoperative photograph (**C**) demonstrating the chronic anterior tibialis tendon rupture, along with the underlying ankle osteophytes seen following an ankle arthrotomy. These osteophytes will be resected to decompress the region for planned anterior tibialis allograft tendon reconstruction.

Absence of AT tendon function can be partially compensated for via recruitment of the extensor hallucis longus (EHL) and extensor digitorum longus (EDL) tendons.[13] Given the atraumatic nature and compensatory recruitment, initial symptoms may be mild, delaying diagnosis and surgical management.

Acute AT tendon ruptures can undergo primary repair if the tendon ends are robust and can be adequately reapproximated or the tendon brought to bone. Missed or neglected injuries lead to tendon attrition and contracture, formation of adhesions, and muscle degeneration. For these cases, reconstructive options include local soft-tissue rearrangement, tendon transfer, free autograft tendon, and intercalary allograft tendon. Acute ruptures can also have underlying tendon degeneration and shredding to warrant an allograft or autograft bridging procedure. Thus, an optimal treatment strategy should be based on patient-specific factors such as functional deficit and desired activity level, but also chronicity, tendon quality and quantity, AT muscle function, and rupture pattern.

Anatomy, Biomechanics, and Pathophysiology

The AT muscle originates from the lateral proximal two-thirds of the tibial shaft. An intermuscular septum separates the AT and EDL tendons. The AT muscle fibers run vertically, forming the tendon at the distal one-third of the leg. The AT tendon passes through the medial aspect of the anterior compartment deep to the superior and inferior extensor retinacula before inserting on the medial and plantar surface of the medial cuneiform and first metatarsal base. Although variants exist, most agree that there are two tendon slips with varying slip thicknesses at the insertion.[14]

The AT tendon is an inverter of the foot and the primary extensor of the ankle, supplying around 80% of dorsiflexion strength, more than the combined efforts of the EHL, EDL, and peroneus tertius tendons.[15] The AT tendon eccentrically contracts during heel strike to allow controlled plantar flexion and undergoes concentric contraction during the swing phase to ensure foot clearance. The plantarflexor myotendinous units account for 83% of overall calf muscle mass, whereas the dorsiflexors, including the AT tendon, account for only 17%.[15]

Proximal AT tendon vascularity arises via branches of the AT artery, whereas the distal tendon blood supply comes from the medial tarsal artery. Although the posterior portion of the tendon has a complete microvascular network extending from the proximal musculotendinous junction to its insertion, the anterior tendon has an avascular segment that is 57 mm in length and centered 10 mm proximal to its insertion. This vascular watershed can

predispose to tendinopathy and subsequent atraumatic rupture.[16] The proposed mechanism of a spontaneous AT tendon rupture is via an acute eccentric loading event of a suddenly plantarflexed ankle in a diseased tendon, such as during a missed step.[2,10,13]

Diagnosis

History

Acute, traumatic AT tendon ruptures usually occur in younger patients who sustain injury via a penetrating object or a distal tibial or talus fracture fragment.[4-6,13] The AT tendon laceration can be missed on initial examination due to distracting injuries or lack of appropriate clinical suspicion. Atraumatic, degenerative AT tendon ruptures typically occur in individuals older than 45 years. Symptoms can be mild as the tendon injury occurs over a series of low-energy events. Although initial weight bearing can be uncomfortable, patients can experience rapid resolution of pain, akin to an Achilles tendon rupture.

Compensatory recruitment of the EHL and EDL tendons and diminishment in pain may lead to lack of injury recognition and delayed presentation.[17] Patients may eventually feel strain in the compensatory muscles similar to spasm or exertional compartment syndrome. Over time, gait difficulties such as weakness and instability, leading to slap foot or steppage gait patterns, can cause patients to seek evaluation and treatment.[3,12,13] In addition, patients may note the appearance of a mass or swelling about the anterior ankle, due to the proximal AT tendon stump, which may be thickened due to tendinopathy or retraction.

Clinical Examination

Patients who present acutely after blunt or penetrating trauma to the anterior ankle should undergo a thorough initial examination of the affected limb, including skin condition and integrity, neurovascular function, areas of tenderness or swelling, palpable tendon discontinuities, and loss of normal resting tension or abnormalities with foot and ankle range of motion.[4-6] In an open laceration, wound exploration and passive ankle positioning may reveal the torn tendon ends. Although the proximal AT tendon end (or other involved extensor tendon/s) is often retracted out of view, appreciation of a tendon void within its respective sheath can also indicate complete tendon laceration.

Atraumatic AT tendon ruptures present with a classic triad, including loss of normal AT tendon contour, appearance of a pseudotumor mass corresponding to the thickened and retracted proximal tendon stump, and weak ankle dorsiflexion, accompanied by toe hyperextension due to extensor tendon recruitment (Figure 2).[17] In the chronic setting, tenderness over the anteromedial ankle is usually absent. Over time, toe extensor recruitment can lead to the development of flexible or rigid deformities (eg, hammering or clawing).[13] Gait should be carefully assessed at varying speeds to elicit a slap foot or steppage pattern.

Imaging

Three standard weight-bearing views of the foot and ankle should be obtained. Although radiographic

Figure 2

A B

A, Clinical appearance of a chronic, right anterior tibialis (AT) tendon rupture. Note the loss of normal tendon definition (longer yellow arrow) seen about the anteromedial ankle compared with the contralateral side (shorter yellow arrow). Furthermore, note the extensor hallucis longus (EHL) and extensor digitorum longus tendon recruitment (red arrows), evidenced by the relative hyperextension seen at the toe metatarsophalangeal joints. **B**, Clinical appearance of a chronic, left AT tendon rupture. Notable here is the loss of normal AT tendon contour over the ankle (yellow arrows), but also the relative hypertrophy of the EHL tendon (red arrow) due to secondary recruitment for ankle dorsiflexion.

findings can be nonspecific, soft-tissue swelling and loss of normal contours about the anterior ankle on a lateral radiograph can be supportive of an AT tendon rupture. Radiographic evaluation may also reveal an avulsed osseous fragment or prominent anterior ankle or dorsal midfoot osteophytes. Ultrasonography can demonstrate AT tendon fiber disorganization and discontinuity, along with a hypoechoic defect at the edge of a retracted proximal stump.[18,19] In either the acute or chronic setting, obtaining an ankle MRI is recommended. MRI will demonstrate the AT tendon rupture pattern and tendon quality, along with any associated injuries or pathology, and can be helpful in surgical planning (Figure 3).[3,20] The thickened, proximal AT tendon stump can give the appearance of a pseudotumor, and the tendon ends can appear wavy, indicative of a complete rupture.

Management

Nonsurgical Treatment

Whether acute or chronic, an AT tendon rupture is generally viewed as a surgical injury. However, with low-demand patients or inappropriate surgical candidates (eg, poor soft-tissue condition, inadequate vascularity, infection, tobacco use, or any medical condition precluding a reconstructive surgery), consideration should be given to nonsurgical management. Conservative care generally includes fitting the patient with a dynamic ankle-foot orthosis, aggressive physical therapy, and activity modifications.

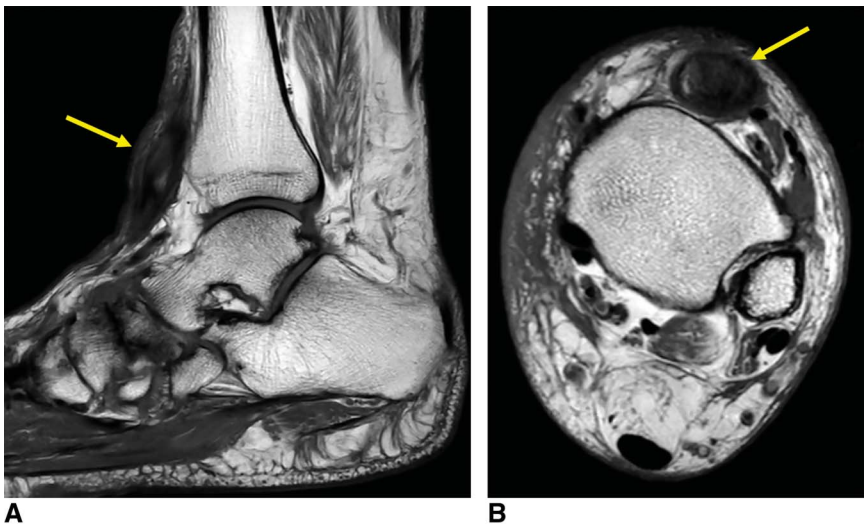
Markarian et al[13] studied 16 patients treated with AT tendon ruptures, including eight patients treated surgically (deemed young active patients) and eight patients treated nonsurgically (deemed elderly, low-demand patients). Five of eight patients in the nonsurgical group had a persistent foot drop at a mean follow-up of 3.86 years, and despite this, no significant difference in outcomes measures was found, likely due to the aforementioned selection bias.

Ouzounian and Anderson[21] reported on 12 patients with AT tendon ruptures, with five patients treated nonsurgically. Three patients either refused bracing treatment or discontinued it, and the other two patients were treated successfully with an ankle-foot orthosis. In elderly, low-demand patients or those deemed poor surgical candidates, bracing treatment can be an effective treatment option.

Surgical Treatment

Most orthopaedic surgeons agree that surgical repair or reconstruction is the most effective treatment for young active patients with an AT tendon rupture to restore active ankle dorsiflexion, strength, and function.[7,13,17] In the acute setting, when possible, primary AT tendon repair should be used to restore the normal length-tension relationship, if the injury is treated within 6 weeks of injury and the tendon stump shows adequate tissue quality.[22] In the subacute setting, the proximal

Figure 3



Sagittal (**A**) and axial (**B**) T1 MRI sequences demonstrating a chronic anterior tibialis tendon rupture. Note the bulbous-shaped, degenerative proximal tendon stump (yellow arrows) retracted to just proximal to the level of the anterior ankle joint at the superior extensor retinaculum, giving the classic pseudotumor appearance to this injury on physical examination.

tendon stump can be retracted and scarred underneath the extensor retinaculum. This scenario can create a sizeable rupture site gap, precluding a successful primary repair and necessitating a reconstructive procedure to restore tendon continuity and function. In chronic situations, there may be considerable AT muscle atrophy, along with an equinus contracture due to the relative overpull of the ankle plantarflexors.

Kopp et al[23] reviewed 10 surgically treated patients with an AT tendon rupture and found significant improvements in American Orthopaedic Foot and Ankle Society (AOFAS) scores and high levels of patient satisfaction. They demonstrated via isokinetic testing that the surgical side exhibited weaker ankle dorsiflexion and inversion compared with the contralateral side, but that this relative weakness did not limit patients in their desired activities. Sammarco et al[17] reported on 18 patients with 19 surgically treated AT tendon ruptures and found significant improvements in AOFAS hindfoot scale scores at a mean follow-up of 53.3 months. In addition, 95% (18/19) of cases exhibited functional ankle dorsiflexion and gait improvements, and 79% (15/19) of cases had full ankle dorsiflexion strength.

Surgical Options and Outcomes

Primary Repair

Although most patients with an AT tendon rupture present in the subacute to chronic setting, for those with an acute traumatic rupture, management should consist of an end-to-end primary repair if tendon quality is adequate. An anteromedial approach centered over the tibialis anterior tendon sheath is used from the superior extensor retinaculum to the medial cuneiform. In the case of an acute laceration, the wound edges are extended proximally and distally for exposure. The ruptured tendon ends are identified and débrided. The repair is performed with nonabsorbable suture using a modified Kessler, Bunnell, or Krackow stitch.[2,3,13]

In insertional ruptures with inadequate distal tendon stump remaining, the proximal stump can be reattached distally using either a suture anchor or a tenodesis screw placed into a bone tunnel into the medial cuneiform for an anatomic repair.[2,11,13] This tendon to bone fixation can be augmented with a suture button flipped on the plantar surface of the medial cuneiform. In cases in which the proximal tendon stump is unable to be repaired back to the medial cuneiform, it can be attached to the navicular or talar neck.[11,13] Caution should be given to this type of nonanatomic repair, which will effectively shorten the AT tendon lever arm, causing dorsiflexion weakness. In these cases, reconstructive procedures, over repair, may be favored.

Gwynne-Jones et al[11] reported on seven patients with AT tendon ruptures. Five patients underwent direct repair, four of which had the AT tendon repaired back to the medial cuneiform and one to the navicular. Four of the five repair patients had no functional limitations, whereas one patient had mild ankle weakness.

Sammarco et al[17] were able to perform a primary or direct repair in 7 of 19 AT tendon ruptures. Of interest, although four of these were early repairs performed within 6 weeks of injury, three were performed in delayed fashion beyond 6 weeks from injury. Regardless of patient age or time to repair, patients exhibited improvements in gait pattern and dorsiflexion strength, along with improvements in AOFAS hindfoot scores compared with preoperative values.[17] Complications were less in the early repair group.

Ellington et al[24] reported on a total of 14 patients with 15 AT tendon ruptures, with 5 undergoing primary repair. At a mean follow-up of 40.3 months, four of five patients expressed complete satisfaction with their outcome and one patient expressed minor reservations. They recommended primary repair for patients if there was adequate AT tendon excursion and proximal stump length.

Funk et al[25] reported on seven patients with AT tendon ruptures, five of whom had direct repair to the medial cuneiform using a tenodesis screw and endobutton fixation. They found that patient Foot and Ankle Ability Measure scores improved from 72.2% preoperatively to 88.8% postoperatively at 1.62 years.

Local Soft-Tissue Reconstruction

In cases in which a primary AT repair is not possible, AT rearrangements or lengthenings have been described. Goetz et al[26] reported on five cases using a Z-plasty lengthening in which the AT tendon is split centrally, detached proximally, and shifted distally to bridge the repair gap. No reruptures were found at a mean follow-up of 22 months. However, gait mechanics were significantly altered as plantar flexion was diminished during the preswing and initial swing phase and increased during the terminal swing phase.

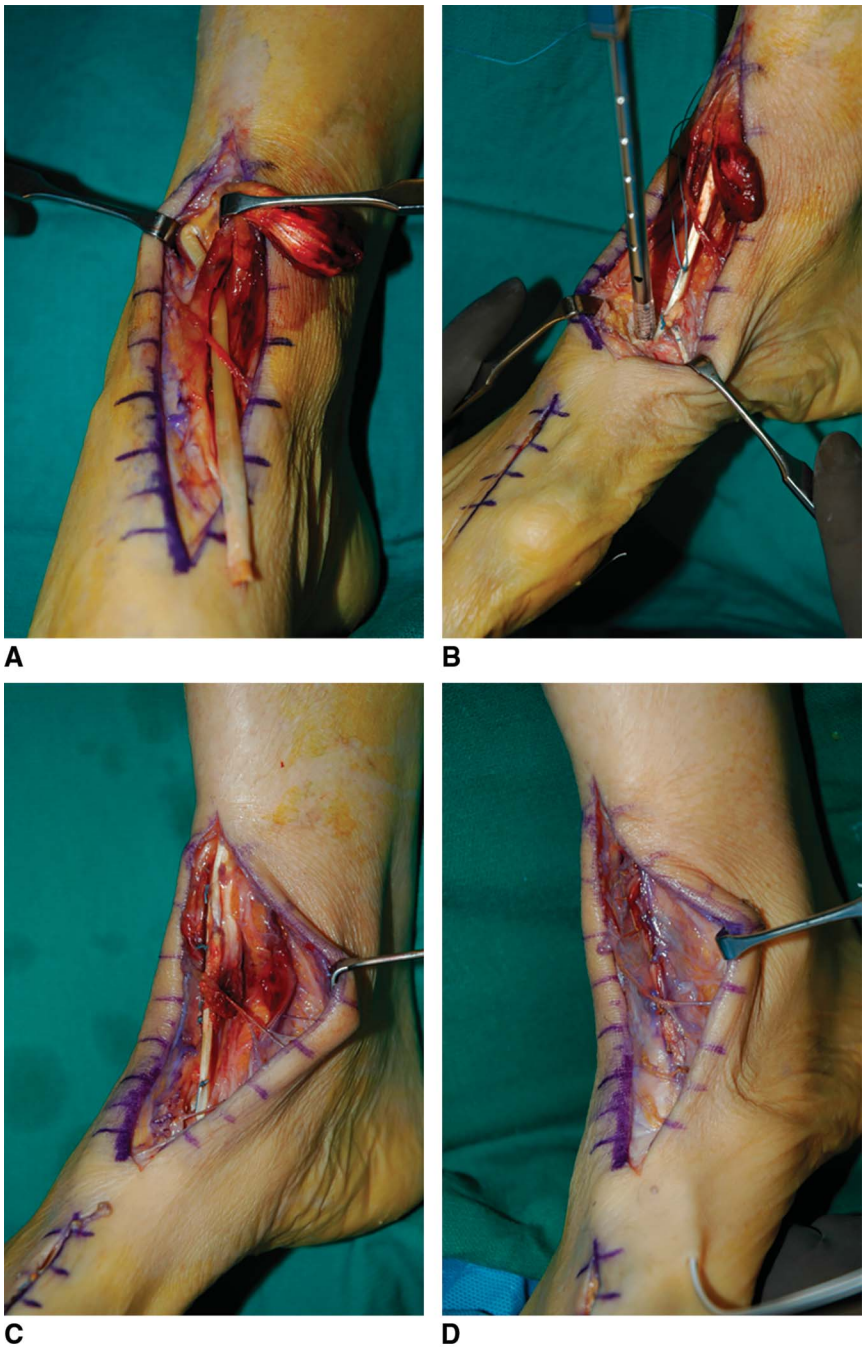
A free sliding AT tendon graft technique has been described for chronic AT tendon ruptures.[27,28] In this procedure, half of the width of the proximal AT tendon stump is excised and reattached to the proximal stump more distally at the appropriate length. This sliding graft can either be repaired to the distal AT tendon stump or

fixed into the medial cuneiform. This local tendon rearrangement is supplemented with a stepped incision and repair of the superior extensor retinaculum. Isolated case reports have described success with this technique. Local AT tendon rearrangements can be considered for AT tendon repair gaps of less than 4 cm.

Tendon Transfer

Historically, transfer of the EHL tendon (Figure 4) has been the most common reconstructive solution for an irreparable, chronic AT tendon rupture, particularly when the AT muscle is not functional. The EHL tendon is harvested distally and either sutured to the distal AT

Figure 4



A, Anterior ankle approach shown with the anterior tibialis (AT) tendon rupture identified proximally and the harvested extensor hallucis longus (EHL) tendon passed through the AT tendon sheath. **B**, Placement of an interference screw for fixation of the EHL tendon into the medial cuneiform. Note the distal incision used for EHL tendon harvest at the dorsal hallux. **C**, Appropriate tensioning and repair of the EHL tendon to the proximal AT tendon stump. **D**, AT tendon sheath repair following tendon transfer.

tendon stump or fixed into the medial cuneiform via a suture anchor or a drill hole with tenodesis screw fixation. The proximal AT tendon stump is sewn to the EHL tendon. Distally, the unharvested EHL tendon stump is tenodesed to the extensor digitorum brevis or EDL tendon, or the hallux interphalangeal joint can be arthrodesed to avoid a drop hallux. The tension of the EHL tendon transfer is set with the ankle in slight dorsiflexion.

Reports on EHL transfer are generally positive. Ellington et al[24] reported an average AOFAS score of 85.6 on nine patients with a mean follow-up of 17.6 months. Three patients were completely satisfied, five had minor reservations, and one had major reservations. Of note, no significant difference was found between the tendon transfer and primary repair groups in any reported outcome. Fraissler et al[29] reported on eight patients with an average AOFAS hindfoot score of 81.0 and a mean ankle dorsiflexion strength of 67% of the contralateral leg at a mean follow-up of 13.5 months. Although one patient had a tendon rerupture, the other seven patients were very satisfied or satisfied with their result.

An EDL tendon transfer, or Kelikian procedure, has been described and involves the harvest of the EDL slips to the second and third toes. These proximal tendon slips are woven through the AT tendon stump and repaired distally to the medial cuneiform. The remaining, distal EDL tendon slips to the second and third toes are tenodesed each to the associated extensor digitorum brevis tendon slip. Only limited case reports exist for this procedure.[13,23,24]

Free Tendon Autograft

In cases in which the adjacent extensor tendons are damaged, not transfer candidates, or not deemed sufficient to bridge the AT tendon rupture defect, a free tendon autograft reconstruction can be performed. As in other areas of the body, the native muscle belly of the compromised tendon end must be viable and functional to successfully incorporate a free tendon autograft or allograft. Tendon autograft sources include the peroneus brevis, peroneus tertius, EDL, Achilles, plantaris, or hamstring tendons.[3,17,30-34]

Sammarco et al[17] reported on 12 patients (four early and eight delayed reconstructions) with AT tendon ruptures that underwent autograft tendon reconstruction, five from the plantaris, four from the EDL, two from the Achilles tendon, and one from the peroneus tertius. All tendon rupture gaps were 3 cm or less, and the tendon autograft was often double or triple folded to increase graft diameter. Graft site was ultimately based on patient anatomy and surgeon preference. The mean preoperative and final postoperative ankle dorsiflexion strength measures were 2.6 and 4.8 of 5, respectively.

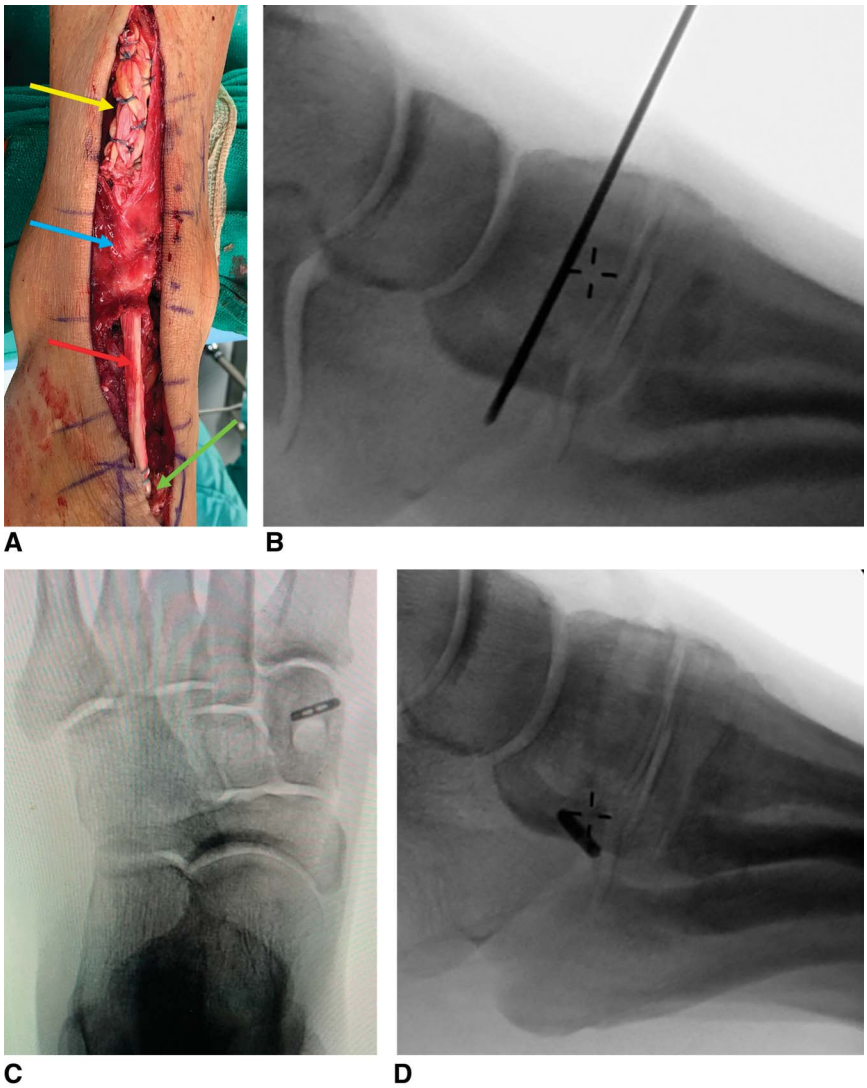
Michels et al[32] reported on 12 patients with AT tendon ruptures, the majority atraumatic, with a mean time of symptom onset to surgery of 11.1 weeks, who underwent AT tendon reconstruction with a semitendinosus autograft. A minimally invasive reconstruction, in which the tendon autograft was anastomosed proximally and then tunneled deep to the extensor retinaculum to its insertion site distally, was used in eight of these patients. The authors reported this to be a reliable technique with overall good results, including good return of dorsiflexion strength and gait. Furthermore, they noted improved wound healing, reduced tendon adhesions, and more expeditious recovery through this minimally invasive approach where the extensor retinaculum was maintained intact. The use of a semitendinosis autograft was noted to have minimal donor site morbidity. This finding allows for the maintenance and balance of the other foot and ankle tendons. Its diameter and length generally match those of the native AT tendon and allow for bridging of large tendon gaps.

Likewise, Karnovsky et al[31] reported on a series of eight patients who underwent minimally invasive AT tendon reconstructions using an autograft hamstring tendon (three gracilis and five semitendinosus tendons). The hamstring autograft was passed into the proximal stump using a Pulvertaft weave and fixated distally using a biotenodesis screw into the medial cuneiform. Patients experienced improvements in their visual analog scale (VAS) pain scale, Short Form-12 (SF-12) scores, and Foot and Ankle Outcome Scores. Range of motion was similar between the surgical and nonsurgical ankles, although dorsiflexion strength remained diminished relative to the contralateral ankle. All patients were able to walk brace free.

Tendon Allograft

The use of allograft tendon has been more recently popularized for the treatment of chronic AT tendon ruptures.[35-38] Benefits include being able to span and reconstruct most any tendon gap, no donor site morbidity, no disruption of foot and ankle agonist-antagonist balance, and reduced surgical times. Allograft tendon options include the Achilles tendon, AT tendon, and hamstring tendons.[35-38] See Supplemental Video 1 for surgical technique.

Figure 5



A, Intraoperative photograph showing an allograft anterior tibialis (AT) tendon reconstruction, maintaining a portion of the extensor retinaculum intact (blue arrow). Proximally, the Pulvertaft weave (yellow arrow) is shown between the native AT tendon stump and the allograft AT tendon. Distally, the allograft tendon (red arrow) spans the chronic tendon defect and is fixated into a drill tunnel placed in the medial cuneiform (green arrow). **B**, Lateral fluoroscopic image demonstrating guidewire placement in the medial cuneiform before reaming (leaving plantar cortex intact) to create a properly positioned and sized tunnel for allograft reconstruction. Final AP (**C**) and lateral (**D**) fluoroscopic views demonstrating the suture button and tenodesis screw construct for secure distal fixation of the AT tendon allograft reconstruction.

Boyette and Nunley[35] described a technique of reconstructing chronic AT tendon ruptures with a tendon defect of over 4 cm using an allograft AT tendon (Figure 5). The AT tendon sheath is incised proximal to the superior extensor retinaculum, which is left intact to prevent bowstringing. The proximal tendon stump is débrided. Distally, there is usually inadequate tendon stump for incorporation with the AT allograft tendon. In this case, the allograft should be fixated into a prepared drill tunnel in the medial cuneiform with an interference screw and a suture button if necessary. Once the allograft AT tendon is prepared, it is passed under the superior extensor retinaculum and sewn into the proximal stump using a Pulvertaft weave. The tension is set with the ankle in dorsiflexion. Myerson et al[36] described a dual-incision technique with the proximal incision placed lateral to the tendon rupture to avoid opening the superior extensor retinaculum and minimize wound complications.

Recent literature demonstrates support for this technique for chronic AT tendon tears. Huh et al[7] followed 11 patients treated with this intercalary allograft technique with a mean follow-up of 43.8 months. They

reported the following mean outcome measures: postoperative dorsiflexion strength of 4.8/5.0, postoperative VAS score of 0.8, Lower Extremity Functional Score of 66.9, SF-12 score of 40.1, and AOFAS score was 84.3. No reruptures or revision surgeries were found. The authors concluded that the technique is safe and reliable without the donor site morbidity associated with tendon transfer or autograft harvest. Similarly, Burton et al[37] reported on four patients with chronic AT tendon ruptures with a gap greater than 10 cm, treated with a double bundle gracilis allograft. At a mean follow-up of 24.5 months, all patients had significant pain relief and a normal gait, along with significant improvements in outcome scores.

Concomitant Techniques

Several studies on AT tendon repair or reconstruction note the concomitant utilization of either a gastrocnemius recession or tendo-Achilles lengthening procedure, based on Silfverskiold testing, to improve ankle dorsiflexion and restore the agonist-antagonist balance of ankle dorsiflexion–plantar flexion.[7,17,24] This finding is also a consideration in patients with equinus of neurologic etiology such as polio, cerebral palsy, and stroke. Likewise, Eckel et al[39] proposed a Botox injection into the gastrocnemius muscle as an adjuvant for posterior tibialis tendon transfers in cases of foot drop to reduce the risk of rupture and facilitate faster rehabilitation by sparing the antagonistic effect of the gastrocnemius during the early recovery period.

Complications

Described complications in the surgical management of AT tendon reconstruction include wound healing issues and infection, stiffness, formation of peritendon adhesions, weakness, donor site complications (in cases of tendon transfers and autografts), superficial peroneal neuritis, and rerupture (Figure 6). Given the limited number of cases reported and variety of reconstructive techniques used, true complication rates are unknown. Appropriate patient selection, delicate soft-tissue handling, minimally invasive techniques, and incision planning may circumvent some of the wound-related complications. Paramount in complication prevention, beyond patient selection, is the proper choice of reconstructive procedure. In a patient with a large chronic defect, an anatomic repair technique or similarly underpowered procedure should not be attempted. Likewise, in the case of an acute rupture, a direct repair may be possible, avoiding complications associated with donor site morbidity or allograft rejection. Treatment should be individually tailored to optimize outcome. Of note, data from a recent multicenter prospective cohort study indicated that patients who underwent direct repair or semitendinosus graft may have superior patient rated postoperative result compared with those who underwent EHL transfer, but this was not statistically significant, possibly due to the limited number of patients enrolled.[40]

Figure 6

Clinical photograph of the anterior ankle on a postoperative anterior tibialis allograft tendon reconstruction patient who developed a wound dehiscence and exposure of the underlying allograft reconstruction. This patient required a return to the operating room for débridement with revision closure and incisional negative pressure dressing. Following this, the patient was able to successfully heal their soft-tissue envelope.

Author's Preferences

For tendon ruptures diagnosed in the acute setting (<6 weeks), an attempt is made for primary end-to-end repair. However, the authors recognize that there is

often inadequate healthy tissue due to underlying degeneration or shredded stump ends and so are ready to perform a tendon allograft procedure with Pulvertaft weave technique proximally and distal suture button and tenodesis screw fixation into the medial cuneiform distally. This technique is also used for subacute and chronic ruptures. Although an EHL transfer can be used when there is fatty infiltration of the muscle belly and extensive muscle atrophy, we feel that a tendon allograft procedure still functions effectively as a checkrein restraint against plantar flexion. A gastrocnemius recession is used for patients with equinus contracture.

Postoperatively, we immobilize for 4 weeks in a postoperative splint and then a cast to ensure adequate soft-tissue and incision healing. Patients are then transitioned into a controlled ankle motion boot and allowed to weight bear to tolerance and initiate physical therapy, with an emphasis on dorsiflexion strengthening and the goal to transition to supportive footwear by 2 months postoperatively. Patients are typically clear for all activity by 3 to 4 months.

Summary

AT tendon ruptures may be a challenging entity to treat, largely due to delayed presentations in atraumatic cases. Unless the patient is not deemed appropriate for surgical management, is low functioning, or chooses to use a brace, surgical intervention is generally recommended. A thorough clinical examination is necessary to make the diagnosis. Primary repair should be performed if the tendon ends can be approximated or the proximal end can be brought to its insertion in distal ruptures. Local soft-tissue reconstruction procedures have been performed for small defects, but have little evidence to support their use. Classically, an EHL tendon transfer was popularized for unrepairable AT tendon ruptures. More recently popularized options include free tendon autograft and allograft reconstruction for chronic AT tendon ruptures. Surgeons should be adept at each reconstructive option to provide the patient with the most optimal procedure and outcome.

References

References printed in **bold type** are those published within the past 5 years.

1. Brüning F: Two rare cases of subcutaneous tendon ruptures. *Münchener Med Wochnschr* 1905;52:1928-1930.

2. Tucker SA, Sammarco GJ, Sammarco VJ: Surgical repair of tibialis anterior tendon rupture. *Tech Foot Ankle Surg* 2012;11:39-44.

3. Anagnostakos K, Bachelier F, Fürst OA, Kelm J: Rupture of the anterior tibial tendon: Three clinical cases, anatomical study, and literature review. *Foot Ankle Int* 2006;27:330-339.

4. DiDomenico LA, Blasko GA, Cane L, Cross DJ: Repair of lacerated anterior tibial tendon with acellular tissue graft augmentation. *J Foot Ankle Surg* 2012;51:642-644.

5. Ebrahimi FV, Tofighi M, Khatibi H: Closed tibial fracture associated with laceration of tibialis anterior tendon. *J Foot Ankle Surg* 2010;49:86-22.e19.

6. Papachristos IV, Dalal RB: Tibialis anterior tendon traumatic rupture secondary to a closed talar neck fracture: A case report. *Foot (Edinb)* 2019;38:76-80.

7. Huh J, Boyette DM, Parekh SG, Nunley JA: 2nd: Allograft reconstruction of chronic tibialis anterior tendon ruptures. *Foot Ankle Int* 2015;36:1180-1189.

8. Siang DKT, Pitarini A, Koo K: Allograft reconstruction of spontaneous tibialis anterior tendon rupture in a diabetic patient. *J Orthop Case Rep* 2019;9:57-60.

9. Vrettakos A, Vampertzis T, Vavilis T, Chaftikis N, Antonoglou G, Papastergiou S: Closed rupture of anterior tibialis tendon after minor injury without medical history: A surgical repair. *J Orthop Case Rep* 2019;9:67-70.

10. Otte S, Klinger HM, Lorenz F, Haerer T: Operative treatment in case of a closed rupture of the anterior tibial tendon. *Arch Orthop Trauma Surg* 2002;122:188-190.

11. Gwynne-Jones D, Garneti N, Wyatt M: Closed tibialis anterior tendon rupture: A case series. *Foot Ankle Int* 2009;30:758-762.

12. Patten A, Pun WK: Spontaneous rupture of the tibialis anterior tendon: A case report and literature review. *Foot Ankle Int* 2000;21:697-700.

13. Markarian GG, Kelikian AS, Brage M, Trainor T, Dias L: Anterior tibialis tendon ruptures: An outcome analysis of operative versus nonoperative treatment. *Foot Ankle Int* 1998;19:792-802.

14. Musial WV: Variations of the terminal insertions of the anterior and posterior tibial muscles in man. *Folia Morphologica* 1963;22:237-247.

15. Jeng CL, Thawait GK, Kwon JY, et al: Relative strengths of the calf muscles based on MRI volume measurements. *Foot Ankle Int* 2012;33:394-399.

16. Petersen W, Stein V, Tillmann B: Blood supply of the tibialis anterior tendon. *Arch Orthop Trauma Surg* 1999;119:371-375.

17. Sammarco VJ, Sammarco GJ, Henning C, Chaim S: Surgical repair of acute and chronic tibialis anterior tendon ruptures. *J Bone Joint Surg Am* 2009;91:325-332.

18. Bianchi S, Zwass A, Abdelwahab IF, Zoccola C: Evaluation of tibialis anterior tendon rupture by ultrasonography. *J Clin Ultrasound* 1994;22:564-566.

19. Bianchi S, Poletti PA, Martinoli C, Abdelwahab IF: Ultrasound appearance of tendon tears. Part 2: Lower extremity and myotendinous tears. *Skeletal Radiol* 2006;35:63-77.

20. Gallo RA, Kolman BH, Daffner RH, Sciulli RL, Roberts CC, DeMeo PJ: MRI of tibialis anterior tendon rupture. *Skeletal Radiol* 2004;33:102-106.

21. Ouzounian TJ, Anderson R: Anterior tibial tendon rupture. *Foot Ankle Int* 1995;16:406-410.

22. Rimoldi RL, Oberlander MA, Waldrop JI, Hunter SC: Acute rupture of the tibialis anterior tendon: A case report. *Foot Ankle* 1991;12:176-177.

23. Kopp FJ, Backus S, Deland JT, O'Malley MJ: Anterior tibial tendon rupture: Results of operative treatment. *Foot Ankle Int* 2007;28:1045-1047.

24. Ellington JK, McCormick J, Marion C, et al: Surgical outcome following tibialis anterior tendon repair. *Foot Ankle Int* 2010;31:412-417.

25. Funk SS, Gallagher B, Thomson AB: Repair of chronic tibialis anterior tendon ruptures. *Orthopedics* 2016;39:e386-90.

26. Goetz J, Beckmann J, Koeck F, Grifka J, Dullien S, Heers G: Gait analysis after tibialis anterior tendon rupture repair using Z-plasty. *J Foot Ankle Surg* 2013;52:598-601.

27. Reb CW, Stenson JF, Daniel JN: Tibialis anterior tendon reconstruction using augmented half-thickness tendon segment transposition. *Foot Ankle Spec* 2017;10:144-148.

28. Wong MW: Traumatic tibialis anterior tendon rupture-delayed repair with free sliding tibialis anterior tendon graft. *Injury* 2004;35:940-944.

29. Fraissler L, Horas K, Bölch S, Raab P, Rudert M, Walcher M: Extensor hallucis longus-transfer for tibialis anterior tendon rupture repair. *Oper Orthop Traumatol* 2019;31:143-148.

30. Forst R, Forst J, Heller KD: Ipsilateral peroneus brevis tendon grafting in a complicated case of traumatic rupture of tibialis anterior tendon. *Foot Ankle Int* 1995;16:440-444.

31. Karnovsky SC, Desandis B, Papson AK, et al: Tibialis anterior reconstruction with hamstring autograft using a minimally invasive approach. *Foot Ankle Int* 2018;39:535-541.

32. Michels F, Van Der Bauwhede J, Oosterlinck D, Thomas S, Guillo S: Minimally invasive repair of the tibialis anterior tendon using a semitendinosus autograft. *Foot Ankle Int* 2014;35:264-271.

33. Stavrou P, Symeonidis PD: Gracilis tendon graft for tibialis anterior tendon reconstruction: A report of two cases. *Foot Ankle Int* 2008;29:742-745.

34. Yamazaki S, Majima T, Yasui K, Kikumoto T, Minami A: Reconstruction of chronic anterior tibial tendon defect using hamstring tendon graft: A case report. *Foot Ankle Int* 2007;28:1190-1193.

35. Boyette DM, Nunley JA: Repair of a chronic anterior tibial tendon rupture using allograft. *Tech Foot Ankle Surg* 2008;7:120-124.

36. Myerson M, Aiyer A, Burger D: Reconstruction of the tibialis anterior tendon with allograft: A novel technique. *Tech Foot Ankle Surg* 2015;14.

37. Burton A, Aydogan U: Repair of chronic tibialis anterior tendon rupture with a major defect using gracilis allograft. *Foot Ankle Spec* 2016;9:345-350.

38. Aderinto J, Gross A: Delayed repair of tibialis anterior tendon rupture with Achilles tendon allograft. *J Foot Ankle Surg* 2011;50:340-342.

39. Eckel TT, Nunley JA: Botox as an adjuvant to tendon transfer for foot drop. *J Surg Orthop Adv* 2013;22:233-236.

40. Johansen JK, Jordan M, Thomas M, Walther M, Simatira AM, Waizy H: Surgical treatment of tibialis anterior tendon rupture. *Foot Ankle Surg* 2020;9:S1268-7731(20)30136-3.