Tibialis Anterior Tendon Injuries

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Dekarlos M. Dial, Hayden L. Hoffler, and John P. Bonvillian

Introduction

Tibialis anterior injuries are rare to the lower extremity with few cases reported in the literature. An injury to this tendon is defined as a partial or complete disruption in the continuity. Injuries to the tendon can produce destabilization, disability, and loss of functionality to the foot and ankle. Although they can occur at all ages, tibialis anterior injuries are more commonly found in older individuals and can be located from the anterior aspect of the distal tibia to the medial arch of the foot. Risk factors for injury include older age, steroid injections, fluoroquinolone usage, inflammatory arthritis, active individuals, and cavus foot structure [1–5]. The mechanism of action is multifactorial and includes internal and external methods of injury. Internally, tendon injuries occur from excessive intensity producing abnormal tension to the tendon, normal intensity in a high-level activity such as sports, and low intensity on a diseased tendon. External injuries to the tendon are due to direct impact, often with a contusion or laceration present. Different treatment modalities are aimed at the various disorders that can come with injury to this tendon. Following an adequate workup and treatment plan, patients are able to return back to normal function.

D. M. Dial (✉) · H. L. Hoffler · J. P. Bonvillian
Podiatric Medicine and Surgery Residency, Department of Orthopaedic Surgery, Wake Forest Baptist Medical Center, Winston-Salem, NC, USA
e-mail: ddial@wakehealth.edu; jpbonvil@wakehealth.edu

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Anatomy

The muscle belly of the tibialis anterior originates from the lateral condyle and upper and middle portions of the lateral shaft of the tibia, interosseous membrane, and the deep surface of the deep fascia [1, 3]. The tendon courses distally across the ankle in a synovial sheath under the medial portion of the superior and inferior extensor retinaculum and inserts on the medial and plantar surfaces of the first cuneiform and first metatarsal [6–8]. There are a couple of classifications that define the insertion location of the tibialis anterior tendon. They are defined by the amount of the tendon that inserts in each portion of the bone [9, 10]. Further classifications divide the insertion of the tendon based on the size of the insertion [11]. Figure 5.1 demonstrates the wide variety of insertions for the tibialis anterior that have been described in the literature. The majority of the literature states that there is an equal insertion of the tendon into the first cuneiform and first metatarsal base (Fig. 5.2).

The tibialis anterior muscle and tendon are supplied by the anterior tibial artery and its branches. Specifically, the anterior tibial recurrent artery provides blood supply proximally, and the medial tarsal artery supplies blood distally (Fig. 5.3). In the early 1990s, Geppert reported homogenous blood supply throughout the tendon, while other literature states that there is a watershed area 10.1 mm from insertion that predisposes the tendon to be injured in the area [12]. The watershed area spans from 45 to 67 mm located under the superior and inferior retinaculum (Fig. 5.4). It is these gliding regions where the tendon changes direction consisting of fibrocartilage which is avascular producing an area susceptible to injury [13].

Tibialis anterior is innervated by the deep peroneal nerve which branches from the common peroneal nerve as it courses inferior to the neck of the fibula. This tendon has numerous functions to the foot and ankle. The tibialis anterior is the strongest dorsiflexor of the foot, supplying 80% of the dorsiflexion at the ankle [14]. Other functions include inverting and adducting the foot, and a key stabilizer of the longitudinal arch. Tibialis anterior is the second strongest inverter to the foot behind the tibialis posterior tendon. This tendon is the antagonist to the peroneus longus tendon which plantarflexes and everts the foot [1, 9, 13]. In gait, along with the other dorsiflexors, tibialis anterior has the two main functions as described by Scheller [15]. They include deceleration of the ground reactive forces at heel strike to prevent foot slap and ground clearance during the swing phase. Using the anatomy of the tibialis anterior, the clinician can adequately diagnose various disorders and provide adequate treatment options based on the structures involved.

Type	Musial (1963) [n/%]	Arhornhurasook and Gaew Im (1990) [n/%]	Brenner (2002) [n/%]	Willegger et al. (2017) [n/%]	Current study – anatomical part [n/%]	Current study – US part [n/%]
Two equal size bands that inserts to the MCB and FM	46/ 37.7	25/ 56.5	43/ 27.6	3/ 7.3	31/ 31	20/ 20
Wider component inserts to the MCB and narrower component inserts to the FM	69/ 56.5	12/ 27.3	71/ 45.5	20/ 48.8	24/ 24	35/ 35
Wider component inserts to the FM and narrower component inserts to the MCB	2/ 1.7	–	37/ 25.6	1/ 2.4	11/ 11	13/ 13
Wider component inserts to the FM and MCB and accessory slip to the distal part of the FM	5/ 4.1	–	–	–	2/ 2	–
Single band inserts to the MCB	–	7/ 15.9	2/ 1.3	–	32/ 32	20/ 20
Two bands inserts to the MCB	–	–	–	–	–	12/ 12
Single band inserts to the FM	–	–	3/ 1.9	–	–	–
Narrow inserts both MCB and FM	–	–	–	17/ 41.5	–	–

Fig. 5.1 Table from Olewnik et al. [10] study demonstrating the wide variety of insertions seen with the tibialis anterior tendon

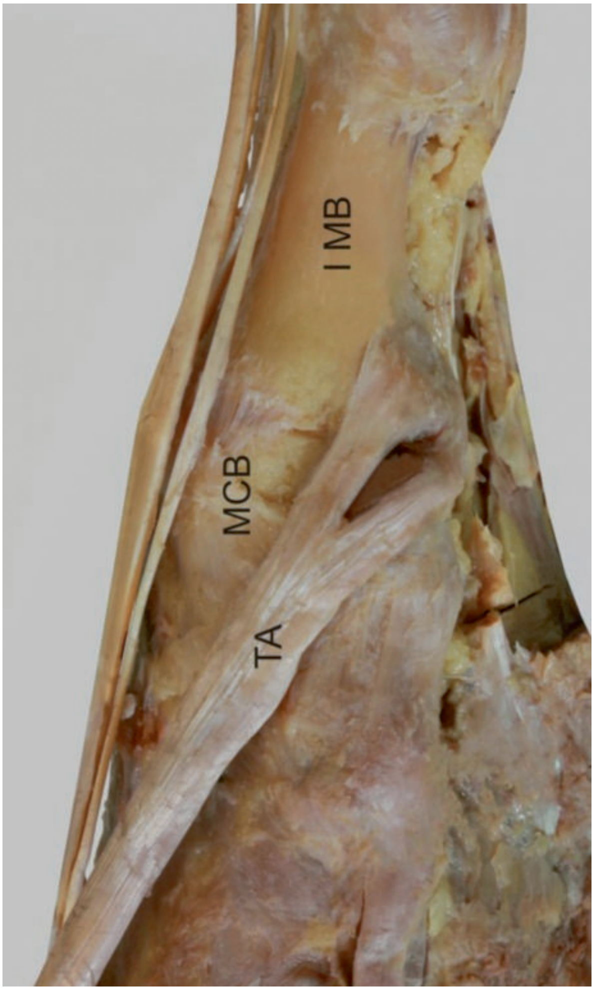


Fig. 5.2 Cadaveric limb demonstrating insertion of the tibialis anterior tendon into the medial cuneiform and first metatarsal base

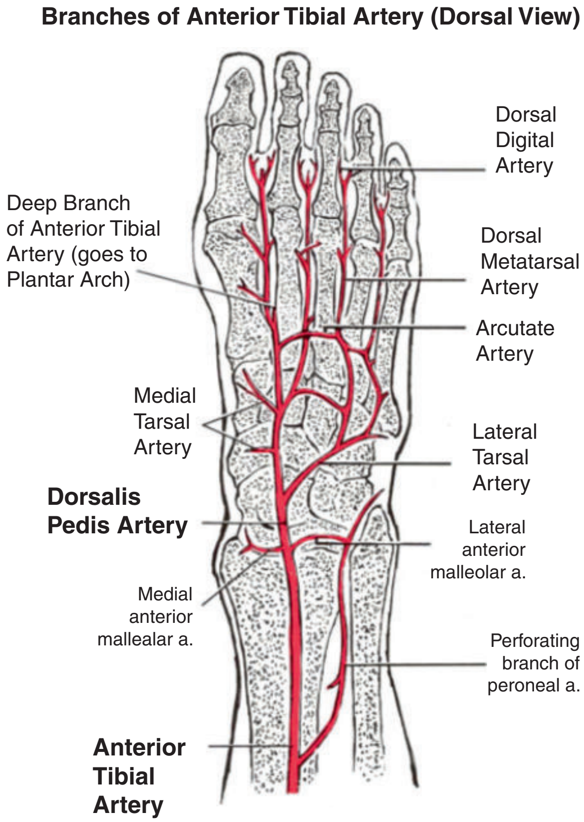


Fig. 5.3 Blood supply of the tibialis anterior supplied distally by the medial tarsal artery which is a branch of the anterior tibial artery

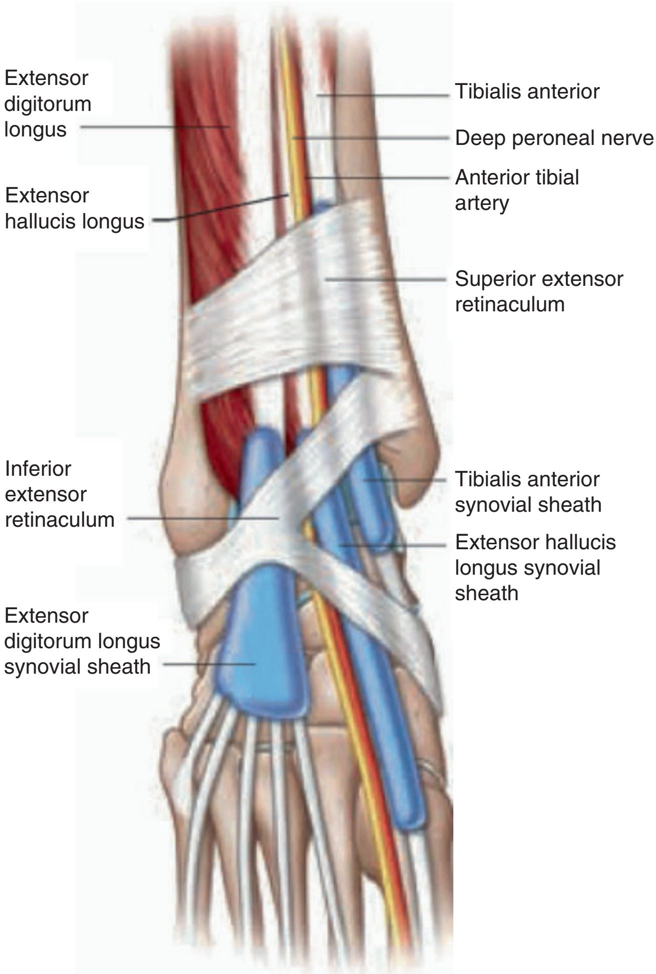


Fig. 5.4 Location of the retinaculum on anterior ankle and foot which is the watershed area of the tibialis anterior tendon

Diagnosis/Clinical Evaluation

Clinical Evaluation

Diagnosing tibialis anterior tendon injuries starts with a proper history and physical examination. Patient's usually recall a specific trauma to the associated foot that caused them immediate pain in discomfort. In other situations, patients describe pain, weakness, and discomfort that has gotten worse over time not remembering a certain incident. Past medical history should be thoroughly examined to look for disorders that put the individual at risk for a tendon injury. These can include diabetes, inflammatory arthritis, history of local corticosteroid injection, or fluoroquinolone use (Fig. 5.5). After a sufficient history, a detailed clinical exam should be performed. Visual inspection is the first indicator of an injury, with pain and weakness often apparent. In acute injuries, there is often pain over the anterior ankle and medial foot with limited dorsiflexion. In chronic injuries, there can be swelling with mass formation over the anterior ankle, drop foot, clawing of the digits, callus formation, and a slapping gait. A unique finding in chronic injuries is that they can be painless due to compensation from adjacent tendons in the anterior compartment of the leg. In 2009, Sammarco described a triad of key indicators of an injury to the tibialis anterior tendon. This included a pseudotumor on the anterior ankle, loss of contour of the tendon, and weak dorsiflexion combined with hyperextension of the toes [16].

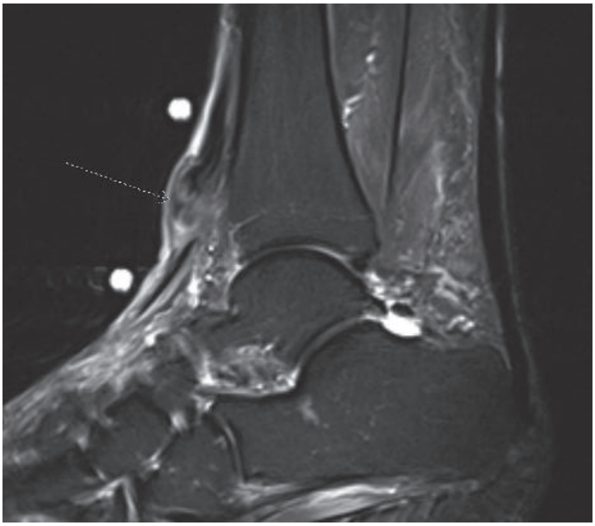


Fig. 5.5 T2 MRI demonstrating a rupture of the tibialis anterior tendon secondary to a local steroid injection

Clinical tests are next initiated to examine the strength and integrity of the tendon. Beginning with palpation, pain, swelling, and discontinuity can sometimes be appreciated as a sign of injury. Palpation should begin from the distal tibial metaphysis and continue to the insertion points of the medial midfoot. Muscle strength is performed by having the patient actively dorsiflex and invert against resistance. In ruptures, strength is decreased but can be normal in tendinopathy, tenosynovitis, and tendonitis. First ray range of motion is another way of assessing injury. In diseased tendons, there is often increased plantarflexion noted of the first ray, due to the lack of dorsiflexion provided by the tendon. The only clinical test with high sensitivity and specificity that has been described for a specific tibialis tendon injury is the Tibialis Anterior Passive Stretch Test (TAPS) for distal tendinopathy [7]. In this maneuver, the ankle is put in plantarflexion, hindfoot eversion, and a midfoot abduction, and pronation force is applied. The test is positive when pain is reproduced or increased [17]. With sufficient clinical testing, adjunctive imaging is performed next to analyze the precise location and extent of the tibialis anterior injury.

Diagnostic Imaging

Radiographs

Plain film radiographs are the initial imaging source commonly used in assessing tibialis anterior tendon injuries because they are the most accessible. They are useful in identifying soft tissue contour and density changes such as a mass on the anterior ankle that can be indicative of a tendon injury [18]. Radiographs also help rule out avulsion fractures at the tendon insertion and other occult fractures associated with the injury (Fig. 5.6). Furthermore, they assist in identifying calcifications that can occur within the tendon.

Ultrasound

Another imaging modality commonly used today is ultrasound. Ultrasound allows a skilled clinician to dynamically evaluate underlying tendon pathology with minimal morbidity to the patient. This modality is useful to assess tendon injuries in patients with underlying hardware which may otherwise obscure the image due to artifact. Fortunately, due to its superficial location in the anterior ankle, the tibialis anterior is easily visualized with a high frequency ultrasound probe (between 12 and 15 Hz). This gives better spatial and contrast resolution. The patient is best positioned with their knee flexed to 45° and their foot flat on a chair. The tendon is examined longitudinally and transversely from the myotendinous junction to the bony insertion. A normal tibialis anterior tendon's appearance is hyperechoic with its diameter twice the size of the other extensor tendons (Fig. 5.7). A diseased tibialis anterior tendon appears hypoechoic with disorganized tendon fibers, interstitial or peritendinous edema, and occasional surrounding fluid present [7, 19].

Fig. 5.6 Anterior posterior radiograph demonstrating an avulsion fracture off the medial cuneiform due to tibialis anterior injury

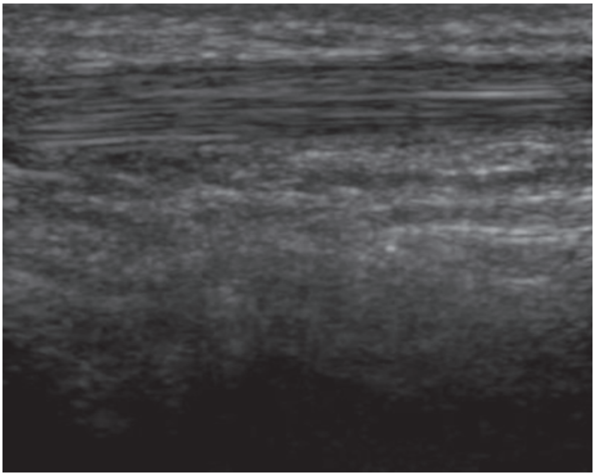


Fig. 5.7 Ultrasound image showing normal hyperechoic signs indicating an intact tibialis anterior tendon

Magnetic Resonance Imaging

The most sought out imaging modality for diagnosis of tibialis anterior injuries is Magnetic Resonance Imaging (MRI) because it can look at all tissues in the foot and ankle [20]. MRI is beneficial in that it is noninvasive and allows for multiplanar imaging. Physicians can look at the TA tendon directly to evaluate for a complete or partial tear, tenosynovitis, and tendinopathy. The normal tibialis anterior appearance is homogenous throughout with thin fibers surrounding the tendon demonstrating the retinaculum. In a diseased tendon, the tibialis anterior can appear heterogenous, with increased signal located around or within the tendon. Partial tear or split longitudinal tears are characterized by increased signal intensity in the intrasubstance of the tendon on a T2 weighted image [19]. A rupture of the tibialis anterior is commonly viewed at the level of the superior extensor retinaculum and is characterized by a complete discontinuity or defect of the tendon [20].

Differential Diagnosis

Anterior Tibial Stress Syndrome

Anterior Tibial Stress Syndrome, also known as "shin splints," is an overuse injury of the distal tibia. It is apparent in 10–15% of all running injuries [21]. It is caused by traction periostitis of the tibialis anterior on the tibia and the interosseous membrane. Risk factors include highly active patients and patients with active overpronation of the subtalar joint. Symptoms of shin splints involve pain along the anterior distal tibia that decreases with activity. Physical exam reveals a tight Achilles, pes planus foot type, and tenderness along the tendon. Upon imaging, X-rays can demonstrate stress fractures of the tibia [22]. More advanced imaging such as an MRI can show periosteal edema along the tibia. Bone scans have even been used to rule out a stress fracture.

Tendinopathy

Distal tendinopathy or tendinosis of the tibialis anterior tendon is not as common as other tendinopathies in the foot and ankle. It is most common in obese females in the fifth to seventh decade. This disorder involves degeneration of the tendon distally, most often occurring at the insertion site. Patients commonly complain of burning, nocturnal pain on the medial side of the midfoot, with pain on palpation at the insertion site [23, 24]. The TAPS test mentioned previously is the most useful test in the diagnosis with sensitivity of 90% and specificity of 95% [17]. Imaging on X-ray is relatively normal, with arthrosis shown in the medial midfoot. Ultrasound is useful, as it demonstrates hypoechoic tendon swelling distally possibly with longitudinal tears that appear fluid filled [7]. More advanced imaging such as an MRI shows tendon thickening, edema within the tendon, and increased signal within the distal aspect of the tendon near the insertion site. Degenerative changes such as osteophytes in the first tarsometatarsal joint, navicular cuneiform joint, and talonavicular joints are often seen [25, 26]. Correlation between the tendinopathy and degenerative changes has not been reported in the literature at this time and is therefore unknown.

Tendonitis

Whenever too much tension is placed on the tibialis anterior tendon, a condition known as tendonitis can form. Tibialis anterior tendonitis is most commonly seen in patients who are involved in active exercises such as running, walking, or kicking. It can also be seen by applying tight shoes or straps over the anterior ankle. Patients complain of pain along the tendon over the anterior ankle that has gradually gotten worse over time. On exam, patients may have pain with resisted dorsiflexion of the foot as well as pain on palpation of the insertion of the tendon at the first metatarsal cuneiform joint. Imaging is not used, as this disorder is a clinical diagnosis.

Tenosynovitis

Tibialis anterior tenosynovitis is another uncommon overuse injury that occurs due to repeated dorsiflexion. It is common in sports such as hiking, cycling, and skiing. Irritation from the upper edge of the shoes can contribute to the inflammation of the tendon. Patients usually complain of pain upon dorsiflexion and palpation to the anterior ankle joint [27]. X-rays are unremarkable for tenosynovitis. Ultrasound reveals hypoechogenic tendon thickening, thickening of the synovial sheath, and fluid collection within the sheath [7]. MRI demonstrates increased signal intensity on a T2 weighted image surrounding the tendon indicative of fluid collection (Fig. 5.8).

Fig. 5.8 T2 MRI demonstrating increased signal intensity surrounding the tibialis anterior tendon consistent with tenosynovitis

Rupture

First described by Brüning in 1905, tears of the tibialis anterior tendon are rare to the foot and ankle literature, with around only a couple hundred reported [28] They are the third most common tendon rupture in the lower extremity behind the Achilles and patellar tendons. The most common mechanism of rupture is a plantarflexed and everted foot combined with contracted tibialis anterior [29]. Ruptures can occur from the myotendinous junction, which is less common to the insertion site. The most common location is 5–30 mm from the insertion point [12]. Although more common as spontaneous ruptures in older people, ruptures can occur in younger individuals through open or closed blunt trauma [7, 30]. Spontaneous ruptures are a result of repetitive microtrauma on a weakened tendon combined with systemic diseases such as diabetes mellitus, hyperparathyroidism, and gout to name a few. Tears due to trauma can be very painful to younger patients. In older individuals, minimal pain is reported across the anterior ankle. Upon physical exam, the outline of the tibialis anterior tendon is not well appreciated. A firm mass can also be noted to the anterior ankle (Fig. 5.9). When placing the foot through ranges of motion, dorsiflexion can appear normal if the integrity of the extensor hallucis longus and extensor digitorum longus is intact. It is this reason that tibialis anterior ruptures often go undiagnosed during the first visit. Chronic ruptures can reveal not only a mass, but calluses underneath the metatarsal heads, clawing of the digits, and foot slap during gait [16, 31]. Radiographs are the first imaging source obtained to rule out accompanied trauma, especially in high energy impact injuries that occur in younger individuals. Ultrasound reveals irregular, hypoechoic, and enlarged tendon fibers, specifically over the lump that forms (Fig. 5.10). Fluid collection can also be apparent surrounding the tendon [7]. On MRI, a complete rupture is indicated by increased signal intensity in a T2 weighted image with tendon discontinuity and proximal retraction of the tendon commonly at the level of the superior extensor

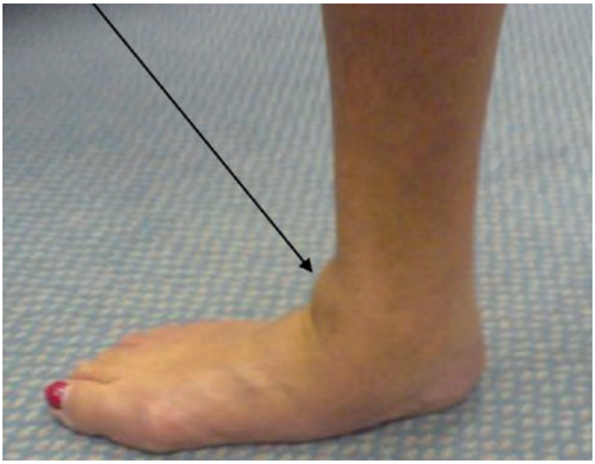


Fig. 5.9 Lateral picture showing a pseudotumor on the anterior ankle indicating a tibialis anterior rupture

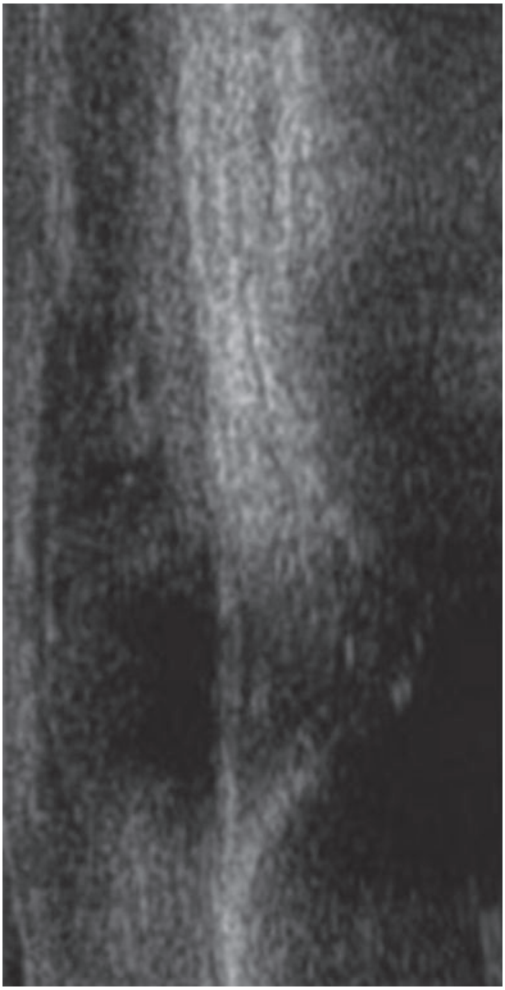


Fig. 5.10 Ultrasound demonstrating hypoechoic changes within the tibialis anterior tendon which are consistent with a rupture

retinaculum. A partial rupture or split longitudinal tear is characterized by increased signal intensity within intrasubstance of the tendon in a T2 weighted image [32, 33]. Overall, an MRI may be useful with preoperative planning.

Other disorders such as lumbar radiculopathy, superficial peroneal nerve entrapment, stress fractures, and compartment syndrome should be included in the differential diagnosis as they present with similar symptoms and exam findings [29, 34–36]. However, these must be ruled out before an appropriate treatment plan can be initiated. With an appropriate neuromuscular exam and imaging, a definitive diagnosis can be obtained, and an adequate treatment plan can be developed to allow the patient to return to normal day to day activities.

Treatment

Conservative

Most injuries of the tibialis anterior tendon can be treated nonoperatively starting with the PRICE protocol. Additionally, nonsteroidal anti-inflammatory medications (NSAIDS), bracing, and physical therapy can be initiated to help with pain, inflammation, and improved function. Steroids are not recommended because they can increase the likelihood of rupture [7, 37, 38]. In ruptures, conservative therapy is indicated in the elderly and less active patients. This involves below the knee cast for 6–8 weeks in a dorsiflexed and inverted position. Due to muscle atrophy from the cast, a decrease in the dorsiflexion can be seen in subsequent follow-up visits. Ankle foot orthotics come into play at this time as they assist in dorsiflexion through the swing phase of gait.

Surgical

Surgical treatment is more often seen in younger patients who would like to maintain a higher level of activity, or ruptures with large gaps that produce obvious functional deficits [39]. For tibialis anterior injuries, there has been surgical treatment that has been described for distal tendinopathy, tenosynovitis, and ruptures.

Tendinopathy

Distal tibialis anterior tendinopathy is usually treated nonoperatively [23, 24]. However, when nonoperative modalities fail, surgical options are considered. Surgical options for DTAT included debridement, augmentation with extensor hallucis longus (EHL) transfer, gastrocnemius recession, and decompressive medial cuneiform exostectomy (DMCE).

A gastrocnemius recession has recently been described in the literature as an adjunct procedure for ruptures but have also been used in DTAT. Contraction of the heel cord, which is an antagonist to the tibialis anterior prevents the ankle from reaching 10° of dorsiflexion which in theory leads to stressing of adjacent structures [24]. Lengthening of the muscle lessens the strain of the antagonist leading to less tension placed on the TA tendon. This decreased the amount of degeneration of tendon fibers seen in tendinopathy.

Another surgical procedure seen in DTAT is the decompressive medial cuneiform exostectomy. This technique involves first debriding the tibialis anterior tendon. While carefully preserving the insertion, the medial prominence of the medial cuneiform is resected in the sagittal plane with an oscillating saw under fluoroscopic guidance (Fig. 5.11). After smoothing the area, the tendon is replaced into the groove, the tenosynovium is excised proximally and a layered closure is performed [25]. Similar to an Achilles tendon procedure, this operation reduces mechanical irritation experienced around the insertion site.

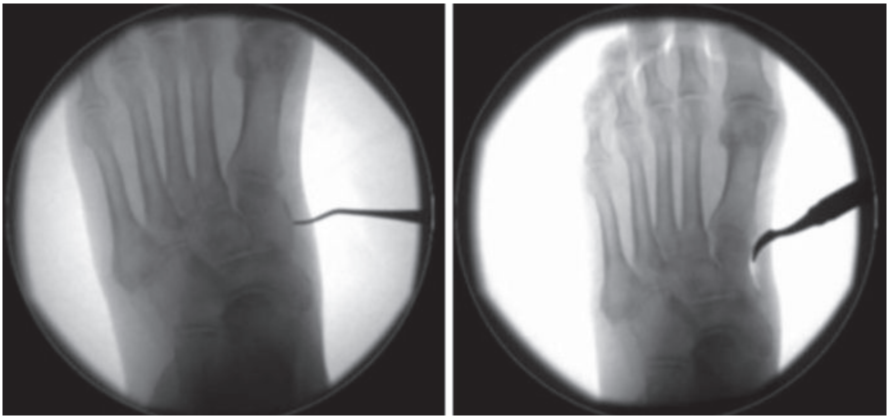


Fig. 5.11 Pre and postoperative anterior posterior fluoroscopic X-rays demonstrating exostectomy of medial cuneiform for tibialis anterior tendinopathy

Tenosynovitis

The only known surgical treatment of the tenosynovitis is excising the synovium. These are commonly done open, however damage to the extensor retinaculum can occur. This produces tendon bowstringing which can precipitate postoperative wound complications. Recently, there has been a push to tendoscopically release the synovium to preserve the integrity of the retinaculum. This is done through three portals: proximal at proximal end of tendon, middle at anterior ankle joint line, and distal at the talonavicular joint. Through these portals, the synovium can be adequately examined, and additionally bone spurs or bursa present can be resected [27].

Ruptures

The repair of tibialis anterior tendon ruptures depends on age, when the rupture occurred, the amount of retraction and how big of a gap there is. For tears that have no retraction, simple end-to-end repair is sufficient [40, 41]. When the tendon is avulsed off the insertion site and minimal retraction is present, reattachment to the bone via tendon anchor or screw is appropriate [18]. If a moderate gap exists between portions of both tendons ends and the tendon is healthy, procedures such as *z* lengthening and turn down flap are explored [42, 43]. However, this can report in an unusual gait pattern, as the tibialis anterior tendon is only 1/3–1/2 the normal size and the tendon to muscle ratio increases [44, 45].

Several grafts have been explored in the literature that help fill in large rupture gaps. These include semitendinosus, gracilis, Achilles, plantaris, peroneus brevis, extensor digitorum longus, and peroneus longus [29, 46–50] (Fig. 5.12). For example, in a peroneus brevis free graft, the proximal and distal ends are sutured to the peroneus longus while the graft is interposed in the rupture location [48]. Free grafts are advantageous in that they cover large tendon gaps with no functional loss or

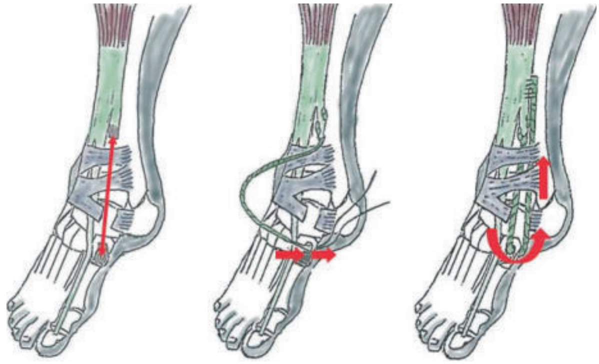


Fig. 5.12 Semitendinosus autograft used to fill in gap after a tibialis anterior rupture

anatomical changes in the foot and ankle (Fig. 5.13). Tendon transfers are also indicated for large gaps. These include the EHL, extensor digitorum longus (EDL), peroneus tertius, and tibialis posterior [5, 23, 39, 51–53]. The EHL and EDL are the most common tendons used in transfers. The EHL transfer, also known as the modified Tohen procedure involves transecting the EHL at the metatarsophalangeal joint and suturing the proximal portion to the medial cuneiform. The tibialis anterior tendon proximally is then sutured to the EHL tendon. The distal aspect of the EHL tendon is sutured to the extensor hallucis brevis (EHB) tendon or sutured to the EDL tendon of the second digit [23, 47]. This transfer is the most common because it's the nearest tendon with a similar function to the tibialis anterior (Fig. 5.14). It also has the additional benefit of eliminating claw toe deformity of the hallux. Using the EDL's second- and third-digit tendon slips, another transfer known as the Kelikian procedure can be performed. This involves the transfer of the second and third EDL tendon slips to the medial cuneiform with the distal aspect of the tendons sutured to the EDB [39, 47]. However, you must be careful of the neurovascular bundle. If a visible contracture of the heel cord is noted, a tendo-Achilles lengthening or gastrocnemius recession should be performed before surgical reconstruction of the tibialis anterior tendon.

Along with all other tendons, tibialis anterior goes through three stages following repair. The first stage is known as the inflammatory phase. This phase lasts about a week and involves the tendon ends being met together and filled in with granulation tissue. Inflammatory cells then move in, producing cytokines and growth factors which lead to the production of fibroblasts. The next stage proliferation lasts several weeks and involves fibroblast proliferation and collagen fibril formation. Lastly, the remodeling phase lasts months and involves collagen fibril alignment and strength [54]. Any disruption in the healing process can delay return to function.

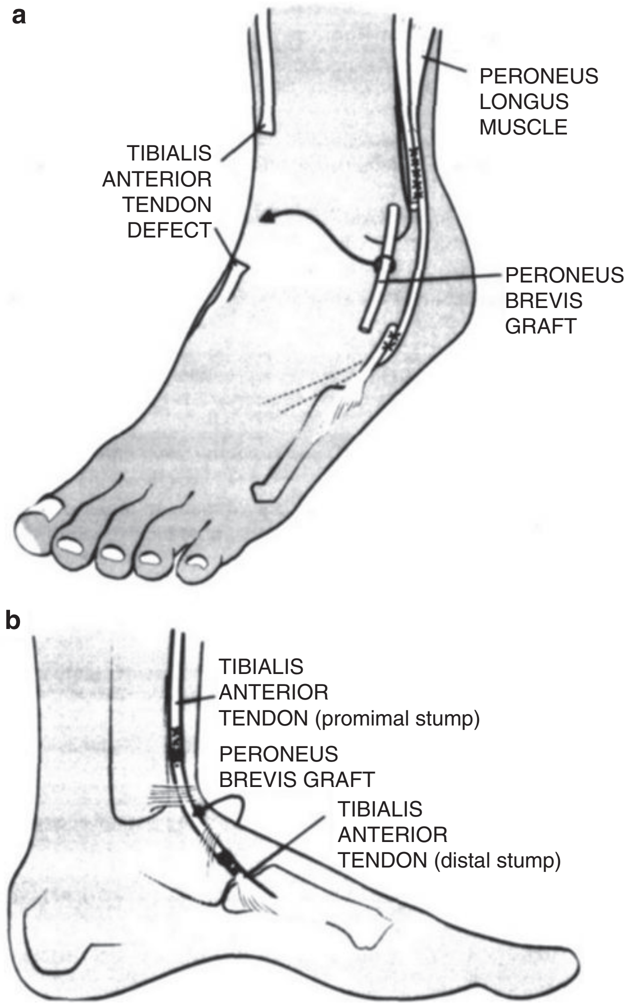


Fig. 5.13 Peroneus brevis free graft used. (**a**) The proximal and distal portions of the tendon are sutured to the peroneus longus. (**b**) The graft is used to fill in the gap of the ruptured tibialis anterior tendon

Post operatively, the patient is non-weight bearing in a cast for 4–6 weeks, with more time spent in patients who received grafts. Then the patient is transitioned to a CAM walker for an additional 6 weeks and physical therapy is initiated to work on range of motion and strengthening exercises. Full weight bearing is initiated at that time. However, patients should not resume full athletic activity until 4–6 months. A full recovery can take up to 1 year. Complications of surgical repair involving

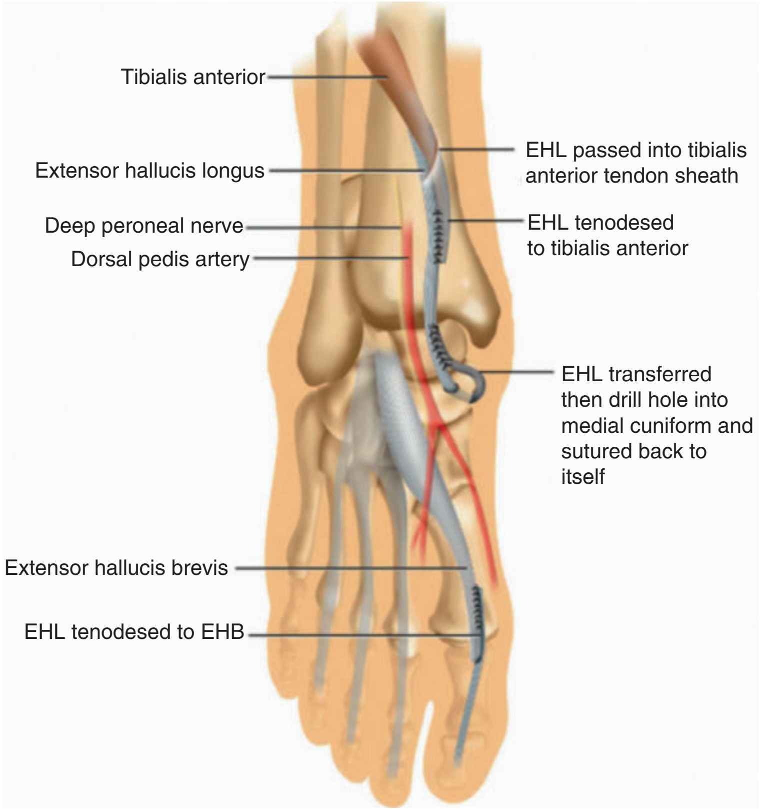


Fig. 5.14 EHL transfer performed to accommodate for tibialis anterior rupture

tibialis anterior injuries include infection, failure of the repair, wound complications, weakness in dorsiflexion, adhesions, and stump neuroma formation. These issues should be addressed on an individual basis to ensure adequate healing, and function is returned in a timely manner.

Evidence Based/Critical Appraisal of the Literature

Comprehensive Literature Search Conforming to PRISMA Statement

A comprehensive literature search was performed, with no time limit to maximize the pool of work available, conforming to the PRISMA statement. The databases used were PubMed, CINAHL, and EMBASE. The terms used for searching were tibialis anterior tendon rupture and repair in human studies. The article abstracts were reviewed, and those that were not involving humans, the management of tibialis anterior tendon injuries, nor had English translation if original articles were not in English were excluded. The search found a literature review of tibialis anterior tendon injuries, which provided further articles that were included, providing 17 studies available for analysis.

Upon review of the literature, injuries to the tibialis anterior are relatively rare [28]. Injuries to the tibialis anterior usually fall into one of several categories including: overuse, degenerative, or traumatic. Overuse injuries usually resolve after a period of conservative treatment, and seldomly require surgical intervention. Although rare, the tibialis anterior is the third most commonly ruptured tendon in the body, following the Achilles and patellar tendons. Ruptures can be either traumatic due to excessive forces acting on the ankle or from direct injury such as a laceration. In older individuals with a past medical history significant for diabetes, local corticosteroid injection, fluoroquinolone use, or gout, degenerative changes to the tibialis anterior may cause a rupture [4]. This rupture may initially be relatively asymptomatic due to the recruitment of the long extensors to aid in dorsiflexion of the foot. A thorough physical exam is of utmost importance to detect any deficiencies in manual muscle testing, any palpable defect along the course of the tendon or subtle findings in the patient's gait. Advanced imaging such as ultrasound (depending on the clinician skill level) or MRI is useful for diagnosis and surgical planning. Intraoperative findings ultimately guide surgical procedure selection based on the percentage of the tendon that is affected for patients with tendinosis and the size of the defect in cases of a complete rupture [40, 41]. Augmentation of the tendon may be necessary for defects larger than 5 cm with tendon allograft or adjacent tendon transfer [29, 46–50]. Post operatively, patients usually are non-weight bearing for 4–6 weeks, followed by a period of protected weight bearing for an additional 6 weeks in a CAM boot.

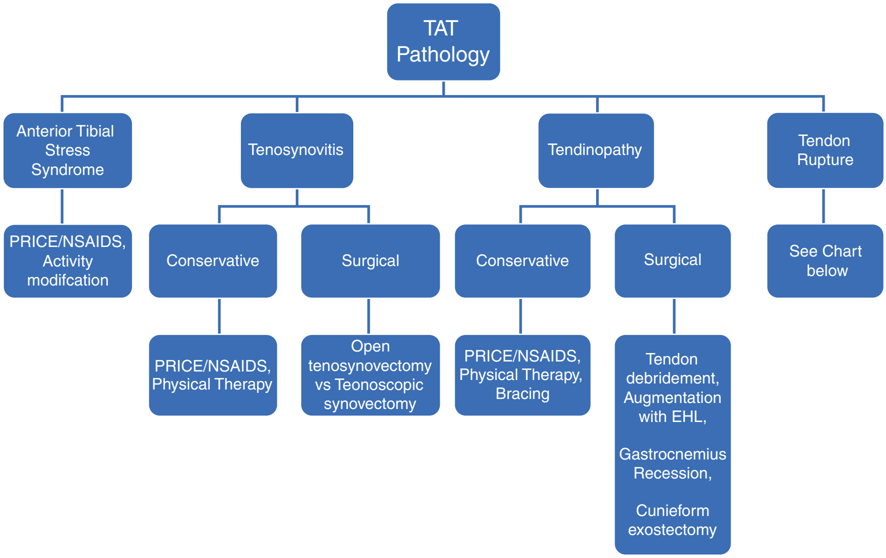
Author	Year	Study design	*N*	Level of evidence	Treatment
Forst et al.	1995	Case report	1	V	Use of ipsilateral peroneus brevis tendon grafting in a complicated case of traumatic rupture of TAT
Markarian et al.	1998	Case report	16	IV	No statistically significant difference between the outcomes operative (8) and nonoperative (8) group
Kausch et al.	1998	Case report	1	IV	Acute TAT rupture with transosseous suture repair
Otte et al.	2002	Case report	1	V	Recommend augmented tenoplasty of the TAT in cases of defects up to 4 cm without functional losses
DiDomenico et al.	2008	Case report	1	IV	Treatment of spontaneous TAT rupture in a DM patient with STAT repair
Gundy et al.	2010	Retrospective case series	11	IV	Debridement and repair of DTAT with EHL augmentation for greater than 50% of the tendon

Author	Year	Study design	*N*	Level of evidence	Treatment
Ellington et al.	2010	Retrospective case series	15	IV	No statistically significant difference between primary tendon repair versus tendon transfer groups when comparing plantarflexion strength or ROM
Aderinto et al.	2011	Case report	1	IV	Delayed repair of TAT rupture with 4 cm deficit with use of Achilles tendon allograft
Goetz et al.	2013	Retrospective study	5	IV	Recommend Z-plasty for ruptures of the TAT with understanding that this technique does not fully restore a physiologic gait pattern
Rajeev et al.	2015	Case report	1	V	Traumatic avulsion of TAT with approximation with a whip stitch and suture anchor
Funk et al.	2015	Case report	7	IV	Repair of TAT rupture using an Endobutton
Huh et al.	2015	Retrospective case series	11	IV	Allograft reconstruction of chronic irreparable TAT ruptures yielded satisfactory strength, pain, and patient reported functional outcomes
Burton et al.	2016	Case report	4	IV	Gracilis allograft reconstruction of TAT with a substantial deficit of greater than 10 cm with favorable results
Patel et al.	2017	Case report	2	IV	Repair of atraumatic TAT rupture with EHL transfer and plantaris autograft
Gossett et al	2019	Case report	1	V	Treatment of DTAT with gastrocnemius recession
Tickner et al.	2019	Systematic review and meta-analysis	134	II	Conservative treatment lead to poorer outcomes when compared to surgical treatment. Use of ipsilateral tibialis split/turn down flap of the TAT, semitendinosus autograft, or direct repair provided the best outcomes compared to EHL autograft
Vosoughi et al.	2020	Retrospective review	81 case reports	IV	For defect <2.5 cm recommend direct repair. Lengthening and rotationplasty procedures for TAT with defects <5 cm. Tendon reconstruction including EHL transfer or tendon allograft for large defects and chronic rupture with significant degeneration. Address any equinus contracture prior to TAT reconstruction

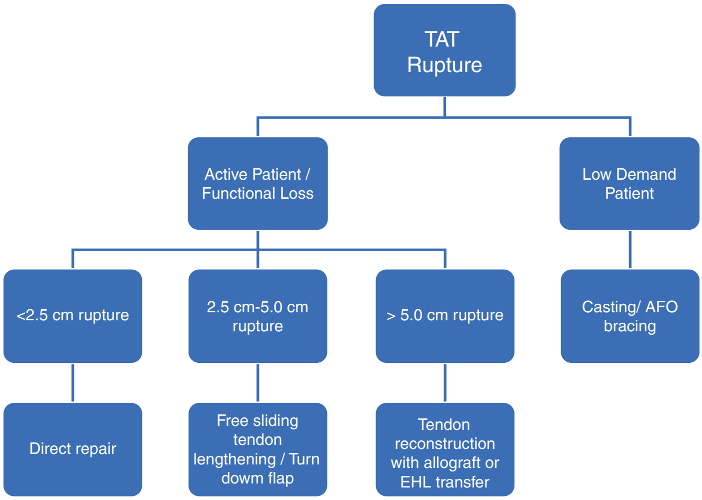
Final Treatment Algorithm

Based on the evidence in the literature and the authors experience, an algorithm can be used to guide treatment for patients with tibialis anterior tendon injuries. As stated above, these injuries can be separated into three broad categories including: overuse injuries, degenerative or chronic tendon injury, or traumatic injury. Patients with overuse type injuries (anterior tibial stress syndrome, insertional tibialis anterior tendonitis, etc.) usually recover with conservative treatment methods alone. These methods include treatments such as PRICE, NSAIDS, appropriate shoe wear, and activity modifications.

In patients with degenerative or chronic tendon injury, the overall patient should be considered. The provider should evaluate things such as the patient's medical comorbidities, activity demand, and functional loss from the injury. In low demand patients with advanced age and multiple comorbidities, conservative management is usually recommended. Treatment options include casting or splinting in dorsiflexion and inversion or an AFO device with or without dorsiflexory assist. In patients with chronic tendon injuries with functional loss that are not of advanced age and are relatively active, surgical intervention may be warranted. The operative procedure depends on the intraoperative findings upon evaluation of the degenerated tendon. When less than 50% of the tendon is involved, operative procedures may include: tendon debridement with tenolysis or tenosynovectomy. If greater than 50% of the tendon is involved or in cases of a neglected tendon rupture, local tendon transfers as well as tendon allograft may be needed to fill large defects [18, 29, 41–50].



Finally, patients with traumatic injuries to the tibialis anterior, including complete or partial tendon rupture, or tendon laceration with functional deficits will likely benefit from surgical intervention. Again, the procedure of choice is dependent on the surgeon's intraoperative findings, specifically the size of the defect as seen in the flow chart below.



In ruptures with less than 2.5 cm of tendon defect, an end-to-end anastomosis is preferred. In ruptures with a defect of 2.6–5.0 cm, lengthening of the tendon will likely be necessary to achieve tendon apposition. Finally, in defects larger than 5.0 cm tendon allograft or local tendon transfers are recommended.

References

1. Rimoldi RL, Oberlander MA, Waldrop JI, et al. Acute rupture of the tibialis anterior tendon: a case report. Foot Ankle. 1991;12:176–7.
2. Trevino S, Baumhauer JF. Tendon injuries of the foot and ankle. Clin Sports Med. 1992;11:727–39.
3. Kashyap S, Prince R. Spontaneous rupture of the tibialis anterior tendon. A case report. Clin Orthop Relat Res. 1987;216:159–61.
4. Velan GJ, Hendel D. Degenerative tear of the tibialis anterior tendon after corticosteroid injection-augmentation with the extensor hallucis longus tendon, case report. Acta Orthop Scand. 1997;68:308–9.
5. Patten A, Pun WK. Spontaneous rupture of the tibialis anterior tendon: a case report and literature review. Foot Ankle Int. 2000;21:697–700.
6. Sobotta J, Paulsen F. Atlas of human anatomy. Elsevier; 2011.

7. Varghese A, Bianchi S. Ultrasound of tibialis anterior muscle and tendon: anatomy, technique of examination, normal and pathologic appearance. J Ultrasound. 2013;17(2):113–23.
8. Saraffian SK. Retaining systems and compartments. In: Patterson D, editor. Anatomy of the foot and ankle: descriptive, topographic, functional. Philadelphia, PA: Lippincott; 1993. p. 113–8.
9. Willegger M, Seyidova N, Schuh R, et al. Anatomical footprint of the tibialis anterior tendon: surgical implications for foot and ankle reconstructions. Biomed Res Int. 2017;2017:1–5.
10. Olewnik L, Podgorski M, Polguj M, et al. A cadaveric and sonographic study of the morphology of the tibialis anterior tendon—a proposal for a new classification. J Foot Ankle Res. 2019;12(1)
11. Musial WW. Variations in the terminal insertions of the anterior and posterior tibial muscles. Folia Morphol (Warsaw). 1963;22:237–47.
12. Geppert MJ, Sobel M, Hannafin JA. Microvasculature of the tibialis anterior tendon. Foot Ankle. 1993;14(5):261–4.
13. Petersen W, Stein V, Bobka T. Blood supply of the tibialis anterior tendon. Arch Orthop Trauma Surg. 1999;119(7–8):371–5.
14. Lavelle, William F. Foot pain. Current therapy in pain, by Howard S. Smith, Saunders/Elsevier, 2009, pp. 189–194.
15. Scheller AD, Kasser JR, Quigley TB. Tendon injuries about the ankle. Orthop Clin North Am. 1980;11:801–11.
16. Sammarco VJ, Sammarco GJ, Henning C, et al. Surgical repair of acute and chronic tibialis anterior tendon ruptures. J Bone Joint Surg Am. 2009;91(2):325–32.
17. Beischer AD, Beamond BM, Jowett AJL, et al. Distal tendinosis of the tibialis anterior tendon. Foot Ankle Int. 2009;30(11):1053–9.
18. Rajeev A, McDonald M, Newby M, et al. Traumatic avulsion of tibialis anterior following an industrial accident: a case report. Int J Surg Case Rep. 2015;14:125–8.
19. Chang A, Miller MT. Imaging of tendons. Sports Health: A Multidisciplinary Approach. 2009;1(4):293–300.
20. Lee MH, Chung CB, Cho JH, et al. Tibialis anterior tendon and extensor retinaculum: imaging in cadavers and patients with tendon tear. Am J Roentgenol. 2006;187(2)
21. Bates P. Shin splints—a literature review. Br J Sports Med. 1985;19(3):132–7.
22. Devas MB. Stress fractures of the tibia in athletes or “shin soreness”. JBone Joint Surg. 1958;40B(2):227–39.
23. Grundy JRB, O’Sullivan RM, Beisher AD. Operative management of distal tibialis anterior tendinopathy. Foot Ankle Int. 2010;31(3):212–9.
24. Gossett L, Gossett PC, Roberts J. Gastrocnemius recession for the treatment of tibialis anterior tendinopathy. Foot Ankle Orthop. 2019;4(3):247301141985294.
25. Laing AJ, Carr C. Decompressive medial cuneiform exostectomy for resistant tibialis anterior insertional tendinopathy. J Foot Ankle Surg. 2018;57(3):531–6.
26. Mengiardi B, Pfirrmann CW, Vienne P, et al. Anterior tibial tendon abnormalities: MR imaging findings. Radiology. 2005;235:977–84.
27. Lee JCY, Lui TH. Tendoscopic synovectomy of tibialis anterior tendon of the ankle. Arthrosc Tech. 2018;7(12)
28. Brüning F. Zwei seltene Fälle von subkutaner Sehnenzerreissung. Münchner Medizinische Wochenschrift. 1905;26(52):1928–9.
29. Tickner A, Thorng S, Martin M, et al. Management of isolated anterior tibial tendon rupture: a systematic review and meta-analysis. J Foot Ankle Surg. 2019;58(2):213–20.

30. Christman-Skieller C, Merz MK, Tansey JP. A systematic review of tibialis anterior tendon rupture treatments and outcomes. Am J Orthop (Belle Mead NJ). 2015;44(4):E94–9.
31. Petersen W, Stein V, Bobka T. Structure of the human tibialis anterior tendon. J Anat. 2000;197(Pt 4):617–25.
32. Khoury NJ, el-Khoury GY, Saltzman CL, et al. Rupture of the anterior tibial tendon: diagnosis by MR imaging. AJR Am J Roentgenol. 1996;167:351–4.
33. Gallo RA, Kolman BH, Daffner RH, et al. MRI of tibialis anterior tendon rupture. Skelet Radiol. 2004;33:102–6.
34. van Acker G, Pingen F, Luitse J, et al. Rupture of the tibialis anterior tendon. Acta Orthop Belg. 2006;72:105–7.
35. Kennelly KD, Shapiro SA, Kumar N, et al. Spontaneous tibialis anterior tendon rupture: a rare cause of foot drop. Neurology. 2007;68:1949–51.
36. Jerome JT, Varghese M, Sankaran B, et al. Tibialis anterior tendon rupture in gout−case report and literature review. Foot Ankle Surg. 2008;14:166–9.
37. Jain K, Asad M, Joshi Y, et al. Tibialis anterior tendon rupture as a complication of first tarsometatarsal joint steroid injection: a case report and review of literature. Foot (Edinb). 2015;25(3):179–81.
38. Gwynne-Jones D, Garneti N, Wyatt M. Closed tibialis anterior tendon rupture: a case series. Foot Ankle Int. 2009;30(8):758–62.
39. Markarian GG, Kelikian AS, Brage M, et al. Anterior tibialis tendon ruptures: an outcome analysis of operative versus nonoperative treatment. Foot Ankle Int. 1998;19:792–802.
40. Neumayer F, Djembi YR, Gerin A, et al. Closed rupture of the tibialis anterior tendon: a report of 2 cases. J Foot Ankle Surg. 2009;48:457–61.
41. Hipp E, Weigert M. Subkutane Ruptur der tibialis-anticus-Sehne. Z Orthop. 1966;101:398–9.
42. Otte S, Klinger HM, Lorenz F, et al. Operative treatment in case of a closed rupture of the anterior tibial tendon. Arch Orthop Trauma Surg. 2002;122:188–90.
43. Trout BM, Hosey G, Wertheimer SJ. Rupture of the tibialis anterior tendon. J Foot Ankle Surg. 2000;39:54–8.
44. Goetz J, Beckmann J, Koeck F, et al. Gait analysis after tibialis anterior tendon rupture repair using Z-plasty. J Foot Ankle Surg. 2013;52:598–601.
45. DiDomenico LA, Williams K, Petrolla AF. Spontaneous rupture of the anterior tibial tendon in a diabetic patient: results of operative treatment. J Foot Ankle Surg. 2008;47:463–7.
46. Burton A, Aydogan U. Repair of chronic tibialis anterior tendon rupture with a major defect using Gracilis allograft. Foot Ankle Spec. 2016;9(4):345–50.
47. Vosoughi AR, Heyes G, Molloy AP, et al. Management of tibialis anterior tendon rupture: recommendations based on the literature review. Foot Ankle Surg. 2019;S1268-7731(19):30099–2. [published online ahead of print, 2019 Jun 21]
48. 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;16:440–4.
49. Patel R, Fallat L. Surgical techniques for repair of atraumatic tibialis anterior tendon ruptures: a report of two cases. J Foot Ankle Surg. 2017;56:1343–9.
50. Aderinto J, Gross A. Delayed repair of tibialis anterior tendon rupture with Achilles tendon allograft. J Foot Ankle Surg. 2011;50:340–2.
51. Dooley BJ, Kudelka P, Menelaus MB. Subcutaneous rupture of the tendon of tibialis anterior. J Bone Jt Surg Br. 1980;62-B:471–2.

52. Ellington JK, McCormick J, Marion C, et al. Surgical outcome following tibialis anterior tendon repair. Foot Ankle Int. 2010;31:412–7.
53. Gaulrapp H, Heimkes B. Peronaeus-tertius-Plastik nach veralteter traumatischer Ruptur der Tibialis-anterior-Sehne (Kasuistik). Unfallchirurg. 1997;100:979–83.
54. Thomopoulos S, Parks WC, Rifkin DB, et al. Mechanisms of tendon injury and repair. J Orthop Res. 2015;33(6):832–9.