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Management of Tibialis Anterior Tendon Rupture

Recommendations based on the Literature Review

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Study was carried out in Bone and Joint Diseases Research Center, Department of Orthopedic Surgery, Shiraz University of Medical Sciences, Iran in collaboration with Trauma and Orthopaedic Department, University Hospital Aintree, Liverpool, United Kingdom

Highlights

- Management of TAT rupture is a topic without a clear consensus in the literature.
- Conservative treatment of TAT rupture is recommended only for low-demand inactive patients with contraindications for surgery.
- It is recommended that for gap less than 2.5 cm, a direct repair under minimal tension should be attempted in all cases of acute traumatic TAT ruptures.

- Lengthening and rotationplasty procedures are recommended for acute traumatic TAT ruptures with gap less than 5 cm in otherwise healthy tendons.
- It is recommended to perform an EHL or EDL transfer (preferably EHL transfer) for large defects after debridement and chronic TAT ruptures with significant tendon degeneration or muscle fatty infiltration.
- It is recommended to perform free tendon graft for large defects after debridement and chronic TAT ruptures with significant tendon degeneration but no muscle fatty infiltration.

ABSTRACT

Tibialis anterior tendon (TAT) rupture is a rare injury that commonly diagnosed late due to mild clinical signs and symptoms. Management of TAT rupture is a topic without a clear consensus in the literature. This current concept review tries to shed some light on the data and treatment. Our extensive literature review identified 81 case reports and case series from 1905 to 2018. Several reported management techniques with their advantages and disadvantages were analyzed and our treatment recommendations are given based on current available evidences.

Levels of Evidence: IV

Key words: Tibialis anterior tendon; Tendon transfer; Allograft; Autograft; Tendon Rupture

INTRODUCTION

The Tibialis Anterior Tendon (TAT) is the principal dorsiflexor of the ankle joint and secondary invertor of the foot. It has important roles in the different stages of gait; in the swing phase, it concentrically dorsiflex the ankle for foot clearance and during plantarflexion of the ankle in the stance phase, it eccentrically contract to stabilize the ankle and prevent damage to the foot and ankle [1]. Although disruption of TAT is a rare condition, it is the third most common ruptured tendon in the lower limb, after the Achilles tendon and Patellar tendon [2].

ANATOMY

The TAT originates from the anterolateral aspect of proximal tibia and interosseous membrane [3]. It passes beneath the superior extensor retinaculum and oblique superomedial and inferomedial limbs of the inferior extensor retinaculum to insert onto the medial cuneiform and the first metatarsal base [4]. Cadaveric exploration by Anagnostakos et al. [5], demonstrated that the TAT inserted only into the medial side of the medial cuneiform in 25% of cases and into the both medial side of the medial cuneiform and the base of the first metatarsal in the other 75 % of cases. Furthermore it was shown that among cases with dual insertion sites, there was an equal insertion at the medial cuneiform and first metatarsal base in about 36 % to 49 % of cases, wide insertion at the medial cuneiform and a narrow insertion at the first metatarsal base in about 49 % to 52 % of cases, and a narrow insertion at the medial cuneiform and a wide insertion at the first metatarsal base in 2% to 11% of cases [5,6].

The blood supply to the TAT is provided proximally by muscular branches of the Anterior Tibial artery and distally by Medial Tarsal arterial branches. They both supply a fine vascular network that perfuse the peritenon with a longitudinal intratendinous blood vessel which is supported by a synovial sheath [7]. The blood flow to the TAT is not equally distributed with a completely vascularized posterior half from the origin to the insertion site and an avascular length of 45 to 67 mm in anterior half of TAT, which is the usual site of degeneration and spontaneous rupture [8]. The avascular zone is situated at the gliding site of the TAT beneath the superior and inferior extensor retinacula. This avascular territory which is 5 to 30 mm proximal to the insertion site does not change with increasing age [3,9]. Avascular tissue of the TAT has been shown to have a poor repair response following repetitive microtrauma especially in cases with comorbidities that resulted in spontaneous rupture [10].

CLASSIFICATION

We searched PubMed, Scopus, and Google Scholar search engines. Search criteria included any article with “Tibialis Anterior” or “Anterior Tibial Tendon” and or “Tear” or “Rupture” in the title. 81 suitable articles were reviewed; they were published between 1905 and 2018. All articles [5,9,11-89] were level IV evidence. In the literature, a TAT rupture can be classified in three different ways:

1. Complete & partial rupture

Most reported ruptures in the literature are complete; however incomplete ruptures [4,5,46,65] and longitudinal split tears in favor of TAT tendinopathy and degeneration [38,40] have been described. In a study using magnetic resonance imaging (MRI) studies

demonstrated that the site of occurrence was at the level of the ankle joint adjacent to the oblique superomedial limb of inferior extensor retinaculum [4]. The inferior retinaculum may therefore be a site for attrition of the tendon and lengthening of the retinaculum may need to be considered during any surgical exploration.

2. Acute & chronic rupture

The literature most frequently refers to acute TAT rupture as those that occur less than 4 weeks from diagnosis and surgical intervention [36,43,76]. The literature refers to those occurring beyond 4 weeks from seeking medical attention as chronic ruptures. The delay in chronic rupture diagnosis reported in the literature on occasion ran into years [23] or even decades [21]. This classification has an important role in TAT rupture treatment strategy. Retraction of the proximal stump of the torn TAT which is often to the level of oblique superomedial limb of inferior extensor retinaculum[4] makes primary repair difficult.

3. Traumatic & atraumatic

Traumatic ruptures are more often seen in younger patients [52,57,86] following open lacerations [51,85,86], blunt trauma with or without a bone avulsion fragment [72,87], or forced plantar flexion and eversion of a dorsiflexed ankle [19,29,36,75,80]. Traumatic TAT ruptures were also reported in closed tibia shaft fractures [25,35,58] and even as a cause of irreducible distal tibia fracture with incarcerated TAT avulsion from medial cuneiform [55]. Iatrogenic traumatic rupture of TAT was seen following the first tarsometatarsal joint arthrodesis and midfoot fusion surgery [32,76], after debridement of distal TAT because of tendinopathy [38], and following local steroid injection [5,43,45,63].

The demographics of atraumatic or spontaneous TAT ruptures, based on 38 reported cases in 14 articles, show they most commonly occur in the elderly (age greater than 60 years) and occur in men more than women [9,11,24,32,43,48,57,63,66,67,71,77-79]. The majority of articles surmised that spontaneous TAT ruptures occur through gradual weakening, overuse and degeneration of the tendon [43,57]. This may also be more prevalent with medical conditions such as diabetes mellitus [24,32,48,52,63], rheumatoid arthritis [43], psoriasis [12], osteoarthritis [76], gout [43,47,68], hypothyroidism [11,76], hypertension [43], prostate cancer [43], and chronic systematic corticosteroid use [76]. Concomitant and sequential ruptures of biceps tendon [43], Achilles tendon [79,81], and the opposite side TAT [71] were reported in some cases.

Distal TAT tendinosis, as a stage before spontaneous rupture, often presents with nighttime burning medial midfoot pain in overweight older patients. Longitudinal split tears in the TAT and osteophyte formation at the first tarsometatarsal or medial naviculocuneiform joints are usually seen [90].

Although fluoroquinolone-related tendinopathy has been described thoroughly for Achilles tendon and other tendons [91], we could not find any in the reported cases of spontaneous TAT rupture. It is contrary to what was expressed in the introduction section of some articles [81].

CLINICAL MANIFESTATION

Although presentations in acute lacerations or direct trauma cases are straight forward, in chronic and atraumatic cases usually the symptoms at the time of TAT rupture are more subtle [21]. Among the published articles, different complaints on admission to the clinics

were reported such as mild pain, localized mass, palpable gap, loss of strength [9,71], instability during gait [9,47], gait disturbances with forefoot dropping and stumbling [19,50,63,67] and high stepping gait [79]. Severe neurogenic pain at the time of presentation due to deep peroneal nerve injury after laceration was reported in one case [76].

In chronic cases, compensation by recruitment of long toe extensor tendons may be seen with resulting toe deformities; such as claw toes and cock-up deformity of the Hallux with possible Achilles tendon (gastrocnemius) shortening [21].

Sammarco et al. described the following classical findings; [76] "physical findings are usually diagnostic and included the classic triad of (1) a pseudotumor at the anterior part of the ankle that corresponded with the ruptured tendon end, (2) loss of the normal contour of the tendon, and (3) weak dorsiflexion of the ankle accompanied by hyperextension of all of the toes."

Ultrasonography and MRI can be helpful to confirm the rupture of TAT and determine the size of the gap between tendon ends [92-95]; however false positive reports have been described [71,79]. Based on our literature review, the differential diagnosis of a missed chronic rupture of the TAT includes TAT peritendinitis, tendonitis and tendinopathies, lumbosacral radiculopathies, peroneal nerve palsy, rheumatic diseases like gout, ankle arthritis, and anterior compartment syndrome [63,81].

MANAGEMENT

Different treatment strategies were described from conservative treatment to a myriad of surgical reconstruction techniques. Several factors should be considered for making a decision how to treat TAT ruptures such as chronicity of the injury, location of rupture or

avulsion, tendon defect length, tendon and muscle tissue quality, concomitant comorbidities, functional demands and patient age [67,76].

Although several articles tried to present guidelines for treatment of TAT rupture [20,76,81,95], no consensus has been reached. In addition, many studies utilized different scores for reporting outcomes. Some of the scores used were insensitive (MRC power grading) and concomitant foot and ankle deformities influenced other score outcomes (AOFAS hindfoot score). Therefore, statistical analysis was impossible and identifying a definitive treatment strategy was difficult. We describe all techniques reported with their advantages and disadvantages, and finally present our recommendations with grade of strength.

Conservative treatment

Use of orthoses, activity modification, and physiotherapy were reported for treatment of TAT ruptures. Nonoperative treatment was reported by several old case reports and series [14,15,18,21,54,60,61,65,74]. Although some reported satisfactory outcome after conservative treatment [15,60], most of the studies described unsatisfactory results with failures, even after long-term physiotherapy [18,24,43,63,66,74,86].

Markarian et al. [54] in a retrospective study (Level of evidence: IV) compared the result of operative and nonoperative treatments of TAT rupture. They found no significant differences between the two groups, but concluded that surgical treatment should be performed for young, high functional demand patients with TAT rupture. Notable limitations of the study were that the two study groups were not case matched and the average age of the operative group was younger than that of the conservative group.

The possible final outcome after conservative treatment was reported by Cohen and Gordon [21] in a case with undiagnosed TAT rupture for 25 years. Their 45 year old male patient presented with hindfoot valgus, flatfoot, instability of metatarsophalangeal joint and claw toe deformities. These were all thought to be muscle imbalance and long term recruitment of toe extensors for ankle dorsiflexion.

Conservative treatment is recommended, according to Michels et al. [57], only for low-demand inactive patients with contraindications for surgery (Grade of recommendation: C).

Operative treatment

Based on our literature review, surgical treatment of TAT rupture was reported to have good functional results [27,41,57,67,76,81,95]. The surgical outcomes do not appear to differ in regard to the age and gender of the patient.[76] By considering chronicity, gap, and location of TAT rupture, several surgical techniques including direct end to end repair [13,14,27,37,42,54,60,63,65,69-71,74,76,82,84,92,94,96], fixation to medial cuneiform or navicular [26,32,54,74], lengthening and rotationplasty procedures [9,24,26,30,48,64,77,80,81,89], tendon transfer [26,27,33,45,52,54,65,67,68,76,78,83], free allograft [11,19,43,66] or autograft [5,31,32,57,67,76,79,85-87] interposition have been reported.

Based on the outcomes reported in the literature, the patient should preoperatively be notified that after the surgery, while muscle power and gait should be acceptable, but some loss of power is expected [52,57].

Direct repair and fixation to the bone:

Direct repair after exploration and debridement of ruptured TAT is the most common reported surgical technique in the literature. Logic would dictate that whenever possible a primary end to end repair under minimal tension is the best for a return to normal function. The literature review has shown that primary repair is successful in all cases with acute lacerations, acute indirect trauma [63,82], and TAT bone avulsion fractures [72]. Interestingly Ellington et al. [27] stated no difference in outcome scores by comparing primary repair with tendon transfer; however the gap, chronicity, and cause of TAT ruptures had not been explained.

For primary repair, the main determinant reported for success was the distance between the two tendon ends and the ability to oppose under minimal tension. Unfortunately gap distance between tendons was poorly described in the literature, and, therefore, determining the maximum gap suitable for primary repair is difficult; however end to end repair with 2.5 cm gap after 2 weeks following indirect trauma was reported [46].

Successful direct repair of acute spontaneous TAT rupture was reported in a diabetic case after local injection [63] and after 5 months in a diabetic woman with spontaneous rupture [71]. Where tendon ends of distal ruptures are friable, reattachment using a Bio-Tenodesis Screw instead of end to end repair or as an augmentation to direct repair has been feasible and strengthened fixation [32,57]. Other authors preferred reconstruction of TAT in the early atraumatic TAT ruptures, suggesting that degeneration of tendons, such as in the chronic pre-rupture phase, makes the primary repair unsafe for spontaneous TAT ruptures [48,57,76]. Currently there is no evidence that one treatment method is superior to another and therefore a practical approach to managing spontaneous ruptures should be taken and the event of irreparable tendinopathy should be prepared for.

Several old case reports or series expressed satisfactory outcomes following direct end to end repair of chronic TAT ruptures without explaining the details of the outcome [42,54,69,76,92,94,96]. One reported case treated by primary repair after 2 years of injury had an unsatisfactory result [37]. Subsequently many believe end-to-end repair of the chronic ruptured TAT is rarely possible. After debridement, a large gap (> 3cm) can result, and reconstruction surgery is required [95].

It is recommended that for gap less than 2.5 cm, a direct repair under minimal tension should be attempted in all cases of acute traumatic TAT ruptures (Grade of recommendation: B). Direct repair with augmentation using fixation of the distal end of TAT to navicular or medial cuneiform bone is an acceptable surgical treatment for acute spontaneous ruptures (Grade of recommendation: D).

Lengthening and rotationplasty procedures:

Two main surgical techniques for lengthening TAT to bridge gaps were described in the literature, a free sliding tendon lengthening of the proximal tendon [9,24,26,30,48,77] and a turn down flap [64,80,81,85,89]. Free z-plasty lengthening for gaps of 5 to 8 cm has been described [9,77,85]. Several turn down flaps techniques have also been explained; longitudinal central 1/3 turn down flap for a 4.5 cm defect [64,80] and dorsal half turn down flap for up to 5 cm gap [24,81]. With lengthening and rotationplasty procedures, the repaired tendon has half to a third of the diameter of TAT and the ratio of tendon to muscle length increases. This likely diminishes the efficacy of the TAT, resulting in function more like a tenodesis. Subsequently, full restoration of physiologic gait pattern is often not achieved. [9,24]

The main pre-requisites for lengthening and rotationplasty procedures is a healthy muscle without fat infiltration and a strong long tendon without degeneration. Degenerated tendons are usually seen in spontaneous TAT ruptures with comorbidities. Fatty infiltration in the muscle following chronic tendon tears is thought to be due to mechanical unloading [97]. Hence, lengthening and rotationplasty procedures will likely be unsuitable for spontaneous TAT ruptures or chronic traumatic cases. This is an important point which has not been evaluated and discussed in the reported cases in the literature.

Lengthening and rotationplasty procedures are recommended for acute traumatic TAT ruptures with gap less than 5 cm in otherwise healthy tendons (Grade of recommendation: C).

Tendon transfer:

The indications for tendon transfer are a large defect, a massively degenerated TAT tendon and marked fatty infiltration of TAT muscle on MRI. The Extensor Hallucis Longus (EHL) [26,27,38,45,52,54,65,67,78,83], Extensor Digitorum Longus (EDL) [27,52,54], Peroneus Tertius [33], and Posterior Tibialis tendon[68] have been described in the literature.

The modified Tohen procedure, defined as transfer of the proximal end of a transected EHL to medial cuneiform and a distal EHL tenodesis to the Extensor Hallucis Brevis (EHB) [54] was the most frequent tendon transfer in our literature review (20 reported cases). The advantages are that the EHL is the nearest tendon to the TAT with agonist action and similar function, it can bypass any size defect in the TAT rupture and it can simultaneously eliminate a deforming force driving a claw toe deformity without any loss of big toe function. To date there has been one reported complication of hallux interphalangeal joint extensor lag [38].

The Kelikian procedure, defined as transfer of 2nd and 3rd EDL tendons to medial cuneiform with tenodesis of 2nd and 3rd EDL distal tendon ends to EDB [54], was the second most common procedure (6 reported cases). The main disadvantage is the hazard of neurovascular damage when channelling the transfer to the navicular bone.

Different EHL or FDL fixation techniques to the medial cuneiform such as by bio-tenodesis screw [45] or bone tunnel with suturing back to itself have been reported with equivocal outcomes [67,78,83]. Although no comparison was done between final outcome of EHL and EDL among three case series on EDL and EHL transfer [52,54], mean of outcome scores after EHL transfers were higher than a single EDL transfer by Ellington et al [27].

It is recommended to perform an EHL or EDL transfer (preferably EHL transfer) for large defects after debridement and chronic TAT ruptures with significant tendon degeneration or muscle fatty infiltration (Grade of recommendation: C).

Free graft interposition:

Once again multiple variances in procedure have been described. Autograft harvest of Semitendinosus [5,57,87], Gracilis [79,86], Achilles [11,66,76], Peroneus Brevis [31], Plantaris [67,76], EDL [65,76] and Allograft reconstruction using Tibialis Anterior [43], Achilles [11,66], Peroneus Longus [43], Gracilis [19] and Semitendinosis[43] tendons have been reported. Large defects even greater than 10 cm have been grafted with satisfactory results [19].

The free graft tendons can be folded several times to achieve a satisfactory overall diameter similar to the original TAT tendon [19,76,86]. Moreover using free tendons enables large defects to be connected with repair to the distal TAT end or fixation to the medial

cuneiform [79]. By using free tendon grafts, there is no need to change the normal anatomy of the foot and ankle region with possible function loss of other tendons.

It appears that harvesting autograft hamstring tendon is more acceptable than Achilles, peroneus brevis, plantaris, and EDL tendons. Long hamstring tendons can bridge any gap between torn tendon ends. Familiarities of most orthopaedic surgeons to hamstring harvesting and minor donor site morbidity are important factors. Finally, as mentioned by Stavrou and Symeonidis [79], the majority of patients with spontaneous TAT rupture are the middle aged and elderly and likely will not have a functional deficit following harvest or require hamstrings for other procedures.

Authors of allograft interposition case series expressed several advantages such as it being safe, cost-effective, a practical option, a reliable alternative, without the donor site morbidity, without sacrificing a local tendon, without alteration in the normal kinematics of the foot and ankle, decreased operative time, and a favorable outcome [19,43]. Although hamstring allograft tendons have been used with good outcomes [19], a better result was reported after using tibialis anterior allograft [43]. It is obvious that tibialis anterior allograft tendon has the diameter and property similar to the torn tendon without needing to fold it, a requirement for hamstring allograft tendons.

There is no study in the literature to compare results of allograft with autograft. Comparing the individual outcomes of allograft and autograft tendons showed an American Orthopaedic Foot & Ankle Society (AOFAS) Ankle-Hindfoot score of 84 for tibialis anterior tendon allograft interposition [43] and about 95 for semitendinosus autograft [57].

It is recommended to perform free tendon graft for large defects after debridement and chronic TAT ruptures with significant tendon degeneration but no muscle fatty infiltration (Grade of recommendation: C).

Concomitant gastrocnemius recession:

Intraoperative Silfverskiold test should be done to reveal any possible equinus contracture [51]. A release should be performed if 5 degrees of dorsiflexion could not be achieved in order to unload the tibialis anterior repair or reconstruction [57,76]. Strayer type gastrocnemius recession [27,32,67,76] and percutaneous tendo-Achilles lengthening [27,78] were reported with similar efficacy.

It is recommended to correct any concomitant equinus contracture before TAT repair or reconstruction (Grade of recommendation: C).

TAT ruptures following corticosteroid injection:

TAT rupture after corticosteroid injection could be managed using tendon reconstruction procedure like EHL transfer or Semitendinosus autograft [5,45,83]; however Neumayer et al.[63] Showed a good result by performing a direct repair in a case being operated 3 weeks after beginning of the symptoms.

RECOMMENDATIONS (Table 1):

- Conservative treatment is appropriate only for low-demand inactive patients with contraindication for surgical procedures.
- For gap less than 2.5 cm, direct repair with or without augmentation using fixation of the distal end of TAT to navicular or medial cuneiform bone should be tried in all cases

of acute rupture. It may be a choice in chronic cases without fatty infiltration in the muscle.

- Lengthening and rotationplasty procedures are recommended for acute traumatic TAT ruptures with gap less than 5 cm.
- Tendon reconstructions including EHL transfer, hamstring autograft, tibialis anterior allograft, and hamstring allograft should be considered for large defects after debridement of tendon ends and chronic ruptures with significant tendon degeneration. For cases with TAT muscle fatty infiltration, free tendon graft is useless and EHL transfer is recommended.
- Correct any concomitant equinus contracture before TAT repair or reconstruction.

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<table>
<tr><td rowspan="2">Types</td><td colspan="3">Gap after debridement</td></tr>
<tr><td>2.5 cm ≤ Gap</td><td>2.5 cm > Gap ≥5 cm</td><td>Gap > 5 cm</td></tr>
<tr><td>Traumatic
Acute</td><td>Direct repair (B)</td><td>➢ Free sliding tendon lengthening (C)
➢ Turn down flap (C)</td><td rowspan="3">Tendon reconstruction (B)</td></tr>
<tr><td>Chronic</td><td>➢ Direct repair (C)
➢ Tendon reconstruction (B)</td><td>Tendon reconstruction (B)</td></tr>
<tr><td>Spontaneous
Acute

Chronic</td><td>➢ Direct repair & augmentation with fixation to bone (D)
➢ Tendon reconstruction (B)
➢ Direct repair (D)
➢ Tendon reconstruction (B)</td><td>Tendon reconstruction (B)</td></tr>
</table>

Table 1: Our recommendation for treatment of tibialis anterior tendon rupture, strength of recommendation in parenthesis.

Table 1: Our recommendation for treatment of tibialis anterior tendon rupture, strength of recommendation in parenthesis.

The recommended tendon reconstruction procedures are EHL transfer, hamstring autograft, tibialis anterior allograft, and hamstring allograft; in cases with TAT muscle fatty infiltration, EHL transfer is the best.