CHAPTER 16

MRI AND THE EVALUATION OF TIBIALIS POSTERIOR DYSFUNCTION

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Over the last five to ten years, there has been a rapid increase in the number of journal articles and studies relating to tibialis posterior dysfunction. Prior to that time the entity was not well-known, understood, or recognized. Two of the pioneers in podiatric medicine regarding this subject were E. Dalton McGlamry, DPM,[1] and Terrence Mueller, DPM.[2,3]

Because of the increased attention that the entity has faced, there is much greater recognition of the common pathology associated with tibialis posterior dysfunction. This includes mid-tarsal joint abduction, subtalar joint eversion, medial column instability, the loss of inversion and plantarflexion power, and often a contracted Achilles.

An epidemiologic study performed by Holmes and Mann, published in 1992, reviewed 67 patients with a mean age of 57.[4] They found a statistical correlation between tibialis posterior rupture and obesity and, to a lesser extent, hypertension. Fifty-two percent of the patients were hypertensive, obese or diabetic. Ten percent of the patients had prior surgery or trauma, and nineteen percent had previous steroid injections in the area of the rupture. Myerson and Allen, in 1989, published a study identifying two main groups of patients.[5] Group A was identified as younger patients with a mean age of 39 years with inflammatory arthropathies and enthesopathy. Group B had a mean age of 64 years, and the deformity was isolated to the tendon itself and thought to be mechanically induced.

The pathology of tibialis posterior dysfunction can probably be exemplified by the studies of Kannus and Jozsa,[6] and that of Frey, Shereff, and Greenidge.[7] Kannus and Jozsa (1991) performed a controlled study evaluating the histopathologic changes that preceded spontaneous tendon rupture. Biopsies of spontaneously ruptured tendons including the achilles, biceps, and a variety of other tendons in 891 patients were studied. Age and sex-matched control specimens were harvested from 445 tendons of previously healthy individuals who suffered accidental deaths. The findings indicated that degenerative changes were common in the tendons of patients older than age 35. These changes have been implicated in spontaneous tendon rupture. No healthy tendon structures were found in any of the spontaneously ruptured tendons. However, two-thirds of the tendons in the control group were shown to be structurally healthy. They concluded from this study that chronic degeneration of the tendon proceeds spontaneous rupture of a tendon.

The study by Frey, Shereff and Greenidge in 1990, reviewed the blood supply to the posterior tibial tendon.[7] The study identified that at the insertion of the tendon, there was an abundant blood supply from the posterior tibial epitenon. At the muscle tendon junction proximally, there was abundant blood supply through the posterior tibial muscular branches. In a mid-substance region of approximately 14 millimeters in length, there was noted to be an area of hypovascularity. This area was noted to be posterior and extending inferior to the medial malleolus. Of interest is that no similar hypovascular zone was identified through the flexor digitorum longus tendon, which usually does not rupture.

In summary, from these articles, we can then speculate as to the pathology involved with tibialis posterior dysfunction. The majority of these patients have a pre-existing collapsing pes valgus condition which undoubtedly creates chronic degeneration of the posterior tibial tendon. This, super-imposed upon the hypovascular area of tendon, would logically seem to be the reason why so many of these ruptures occur, particularly in the fifth and sixth decades of life.

CLASSIFICATION

A variety of classification and staging systems have been described. Mueller proposed a classification system based upon four categories: direct injury, pathologic rupture, idiopathic rupture, and functional rupture.[3] Mahan, in 1992, described an etiologic classification system with three categories: direct injury, pathologic rupture associated with inflammatory arthropathies, and a mechanical vascular mechanism (Podiatry Institute Annual Seminar, April 1992). The third category is based upon spontaneous rupture secondary to pre-existing hypo-vascularity and mechanical degeneration of the tendon. The mechanics and evaluation of tibialis posterior dysfunction have been thoroughly described by Mueller in 1984,[2] and 1991.[3] Banks and McGlamry also provided a comprehensive description of posterior tibial tendon rupture in 1987.[1]

In 1989, Johnson and Strohm proposed a staging system for tibialis posterior dysfunction.[8] Stage I demonstrates peritendinitis and/or tendon elongation, normal alignment of the rearfoot, mild weakness or single heel rise, and mild to moderate focal pain. Stage II is characterized by elongation of the tendon, flexible valgus position of the hindfoot, moderate pain along the tibialis posterior tendon, marked weakness on single heel rise, and the "too many toes sign." Stage III demonstrates elongation of the tendon, fixed valgus position of the heel, medial and lateral pain, marked weakness on single heel toe raise, and the "too many toes sign." The following treatment regimen was suggested. Stage I injuries were treated with conservative care for three months, followed by synovectomy and tendon debridement if necessary. Transfer of the flexor digitorum longus to the navicular was suggested for Stage II injuries. However, subtalar arthrodesis was proposed for a Stage III tibialis posterior dysfunction.

In 1986, Funk et al. reported the results of surgical exploration of nineteen patients with tibialis posterior dysfunction.[9] Four types of lesions were identified: avulsion at the insertion, mid-substance tendon ruptures, incontinuity tears of the tendon, and tenosynovitis only. The patients with Type I lesions were treated with surgical re-insertion of the tendon. These patients overall had a poor outcome at follow-up. Patients with type two, three, and four lesions showed both subjective and objective improvement. Patients with mid-substance tendon ruptures were treated by transfer of the flexor digitorum longus tendon. Patients with type three and four lesions were treated with tendon sheath synovectomy.

DIAGNOSIS

The greatest difficulty in dealing with tibialis posterior dysfunction is the delay that frequently occurs prior to an accurate diagnosis. This delay predominately results from two factors: the condition results from a chronic mechanical overload on the foot and ankle and therefore the onset is quite gradual rather than acute; and unless the clinician has a high index of suspicion, it is very easy to miss the diagnosis.

The delay in diagnosis may be very substantial because patients often will not report symptoms on the medial side of the foot, as much as on the lateral side of the foot. Some patients may present with pain more characteristic of sinus tarsitis, heel pain and plantar fascitis as a result of the collapse of the foot. Other patients, (about 10% in the author's review of patients), may present with symptoms consistent with tarsal tunnel syndrome. Flexor substitution type hammertoes can also develop and divert attention to the forefoot. The delay in diagnosis therefore results in a progression in the collapse of the foot. The medial column will collapse in the sagittal plane and there will be a transverse plane abduction occurring at the midtarsal joint. Eventually the development of degenerative joint disease in these and other joints can make treatment more difficult.

If the clinician has a high index of suspicion for tibialis posterior dysfunction, then diagnosis by means of manual testing is possible. The difficulty with manual muscle testing for this condition is that these patients have often become quite skillful at substituting with tibialis anterior. These patients can therefore have strong inversion strength. The technique for evaluation must consist of placing the patient's foot in a fully plantarflexed and adducted position, and having the patient resist an eversion force.

Other findings associated with tibialis posterior dysfunction include an asymmetric flatfoot, particularly with a greatly increased abduction of the forefoot on the rearfoot. This abduction creates the "too many toes sign" (the examiner sees from behind more of the lateral digits when observing the patient walking because of the amount of forefoot abduction). An important test is the single limb support test. If the patient cannot raise up on one side unsupported, then that clearly indicates a deficiency in plantarflexory power. In a double limb support one looks to see whether the calcaneus inverts while the heel is elevated. This helps to evaluate for the flexibility of the deformity.

Signs of acute inflammation or injury may often be absent. There will be swelling and increased skin temperature only if there is continuing acute tendinitis. Frequently, these symptoms are absent because the tendon has already ruptured. Radiographic findings are variable, depending upon the degree of collapse of the foot. Generally, one can expect to see abduction at the midtarsal joint on the AP view which presents as an increased calcaneocuboid angle, as well as a large increase in the talocalcaneal angle. The navicular will be subluxed laterally on the head of the talus. On the lateral view, one can see a collapse in the sagittal plane of the medial column with plantarflexion of the talus, navicular cuneiform faults, dorsiflexion through the first metatarsal cuneiform joint and sometimes lateral column breakdown as well. The radiographs may also reveal the presence of an os tibiale externum. In 1996, the author reported an incidence of 60% presence of os tibiale externum in a group of patients with tibialis posterior dysfunction at the Pennsylvania College of Podiatric Medicine (Podiatry Institute Annual Seminar, April 1996). This contrasts with an overall incidence in the population of perhaps 10% to 15%.

MRI AND TIBIALIS POSTERIOR DYSFUNCTION

The need for better imaging studies in the evaluation of tibialis posterior dysfunction is clear. Clinical evaluation can be suspect and more importantly, it is impossible to predict from the clinical evaluation the exact condition of the tendon to determine whether or not the tendon can be salvaged as part of the repair. MRI in tibialis posterior dysfunction has the following purposes: 1) To determine whether the problem is caused by a disorder with tibialis posterior tendon or some other problem (Figs. 1-3); 2) To identify whether or not the tendon can be salvaged as part of the tendon repair (Figs. 4A, 4B, 5); 3) To identify other pathology co-existing with the tibialis posterior dysfunction; and 4) To act as an aid in the planning of surgical procedures.

For a time, CT scans were used to evaluate the posterior tibial tendon. Rosenberg et al., in 1988, identified three patterns of rupture.[10] These included the Type I which was present 46% of the

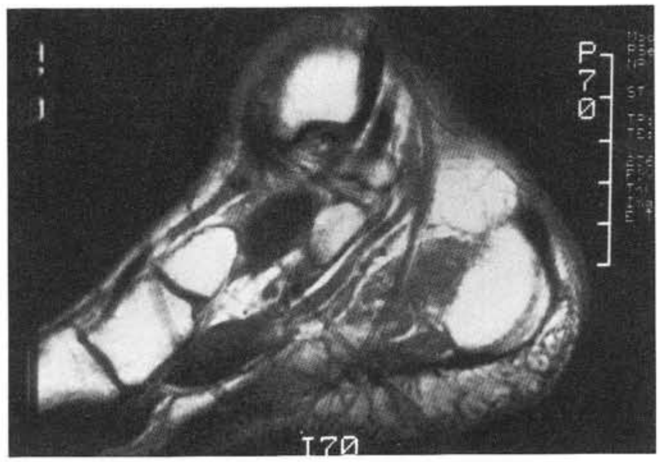

Figure 1. Sagittal image demonstrating significant increased signal intensity at the insertion of tibialis posterior into the navicular. Note that proximal to the area of increased intensity, there is a gap before the tendon is reconstituted again behind the medial malleolus.

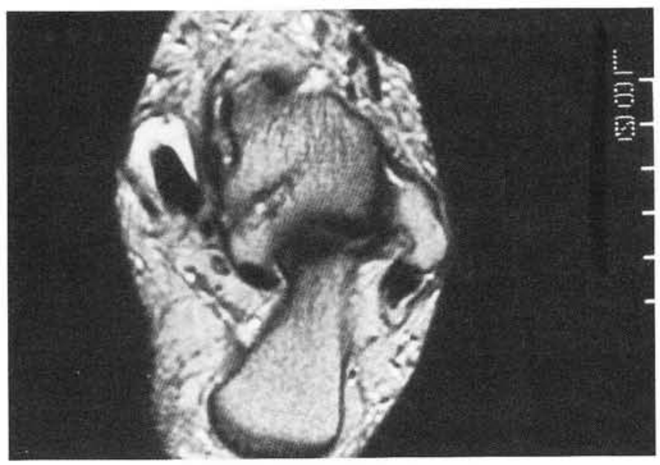

Figure 2. Coronal section of MRI of right foot. Notice the large clear space around the tibialis posterior tendon, indicative of significant fluid. Also note the hypertrophy of the tendon.

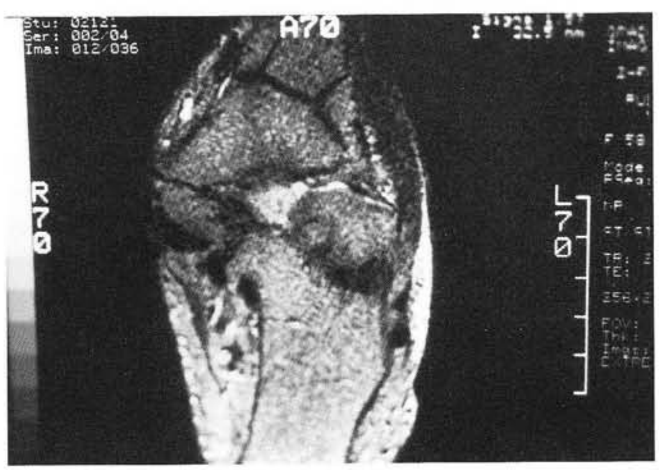

Figure 3. MRI section of right foot demonstrating fracture on the medial side of the navicular. This patient had a traumatic injury and was diagnosed with tibialis posterior tendinitis or dysfunction. The fracture had not been visible on x-ray.

Figure 4A. This patient is a 56-year-old heavy-set white female who had presented with medial arch pain. Presented is the sagittal image demonstrating organized and heterogenous appearance of tibialis posterior tendon. Note the stringy or wavy appearance to the tendon.

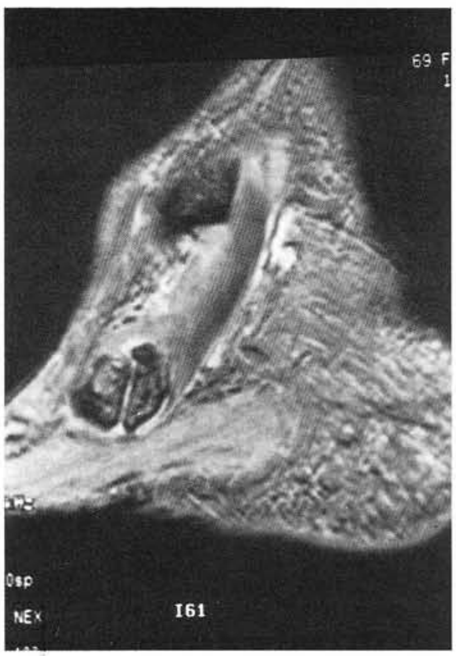

Figure 5. This is a 64-year-old heavy-set white female who presented with medial arch pain. She had already previously undergone a triple arthrodesis on her other foot for tibialis posterior dysfunction. On this foot, she was successfully treated with an Evans calcaneal osteotomy and navicular cuneiform and Lapidus fusions along with a flexor digitorum longus tendon transfer. The MRI shows the presence of an os tibiale externum and demonstrates clearly that the vast majority of the tendon inserted into the os tibiale externum. The tendon itself is demonstrating significant heterogeneity and hypertrophy. Intra-operative inspection revealed the tendon to be extremely hypertrophic with deep longitudinal tears and significant intra-mural degeneration.

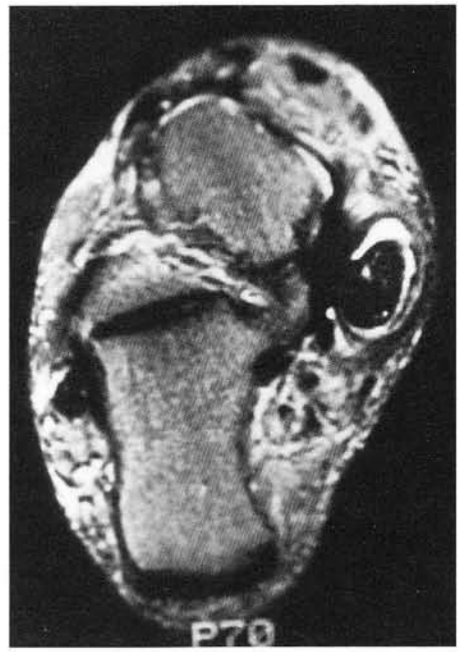

Figure 4B. Note the large area of fluid surrounding the tibialis posterior tendon medially. In addition, you can see significant heterogenous character to the tibialis posterior tendon itself. Intra-operative inspection revealed the tendon to be the consistency of gelatin.

time and which was significantly hypertrophic, Type II which was present 16% of the time and which demonstrated significant tapering and elongation of the tendon, and Type III where a visible rupture was present. Longitudinal splits observable intraoperatively were not usually identified on the CT scan.

A normal MRI of the posterior tibial tendon will identify the tendon to be homogeneous with low signal intensity. The insertion is more heterogeneous and shows increased intensity. An abnormal tibialis posterior MRI will show increased signal intensity on the T1, and intra-substance necrosis and sheath fluid on the T2 at the site of involvement. Serial coronal sections are necessary because the sagittal sections may demonstrate an incomplete view of the tendon. Longitudinal splitting is best seen on cross-sectional views, and will demonstrate heterogenous light intensity. Tendon degeneration will be demonstrated by enlarged heterogenous areas.

In 1987, Alexander, Johnson, and Berquist reviewed the use of MRI in tibialis posterior rupture.[11] They indicated that "in most cases, clinical evaluation is sufficient to make the correct diagnosis, but MRI can be useful in the evaluation of patients with suspected disruption of the posterior tibial tendon lacking the usual physical signs." Rosenberg et al., in 1988, compared CT and MRI findings.[12] They identified that the MRI is highly sensitive but that under-estimation of the extent of the lesion could occur. They determined that the overall accuracy (surgically confirmed) was 59% for CT scan and 73% for MRI.

An important reason for the use of MRI is that surgical inspection of the tendon is often not accurate. Jahss stated that "the preoperative MRIs have proved more accurate and can evaluate objectively the internal degeneration of the entire tibialis posterior tendon compared with the limited evaluation provided by surgical inspection (Fig. 6)." The best study regarding tibialis posterior dysfunction and MRI was that by Conti, Michelson, and Jahss in 1992. They performed 40 preoperative MRIs with intraoperative surgical grading. They then followed these patients who had soft tissue repair for tibialis posterior dysfunction, and determined whether or not the surgical or MRI classifications were predictive. They determined that surgical grading did not correlate with outcome following reconstruction. MRI grading did significantly correlate with outcome, and the overall association between surgical and MRI classification was only 40%. They indicate that "the superior sensitivity of MRI for detecting intra-mural degeneration in the posterior tibial tendon that was not obvious at surgery may explain why MRI is better than intraoperative tendon inspection for predicting the outcome of reconstructive surgery."

This has been the author's experience as well. Frequently, patients have been seen who have had prior surgeries where their tibialis posterior tendon was inspected intraoperatively and determined to be normal in appearance. These patients then had tendons that continued to deteriorate, perhaps accentuated by the surgical trauma, and then went on to full rupture with obvious defects on MRI. The author believes the use of MRI in tibialis posterior dysfunction can be particularly important in determining whether or not a flexor digitorum longus transfer can be used as the primary medial procedure. If the posterior tibial tendon has very significant intra-mural degeneration as well as either hypertrophy or narrowing, then flexor digitorum longus transfer is not utilized as a primary procedure, but merely as a secondary adjunct. In these cases the author might be more likely to perform a Cobb-type procedure with autogenous grafting along the course of the tibialis posterior

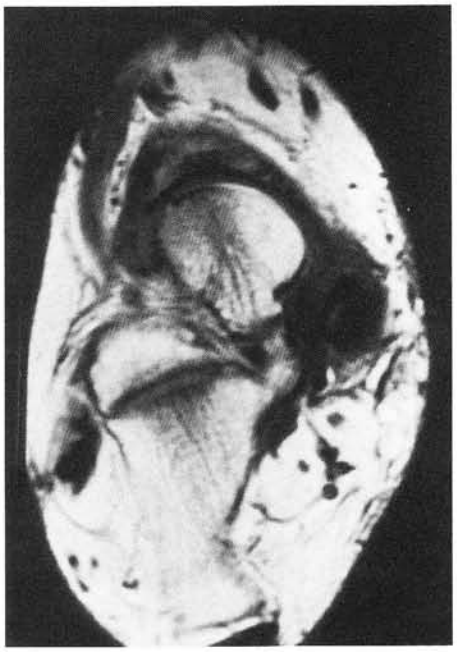

Figure 6. Coronal section showing massive hypertrophy of the tibialis posterior tendon as it approaches the insertion into the navicular. This 65-year old heavy-set white female had previously had surgical exploration of this tendon by another surgeon. His inspection at that time did not reveal any abnormalities of the tendon. He did not have the benefit of an MRI. The tendon is clearly hypertrophic and was the cause of her pain in this area.

tendon. Similarly, the MRI may demonstrate that there is a limited focal area of defect within the tendon that may lend itself to a medial procedure consisting of excision of the defect and tendon grafting or primary repair. This cannot always be confirmed by intraoperative inspection. Many times, intraoperative inspection may reveal a somewhat hypertrophic tendon, but it may not reveal the longitudinal splits and intra-mural degeneration that are existing within the tendon. Failure to identify these defects would result in inadequate treatment. Medial column soft tissue repairs do not seem indicated for primary repair of this disorder when the defect is very extensive throughout the tibialis posterior tendon, or when a full rupture exists.

It is also important to note that additional pathology may be identified on the MRI. This can include significant fluid within the flexor digitorum longus or flexor hallucis longus sheaths and/or degeneration of one of both of those tendons. If the flexor digitorum longus is determined to be deteriorated on MRI, then clearly it is not adequate for transfer. Other types of pathology may be demonstrated as well, including increased signal uptake in the Achilles tendon, sinus tarsi syndrome, osteochondral defects in the ankle, attenuation of the spring ligament or deltoid ligament, and other deteriorated joints.

It is not sufficient alone to request an MRI and then simply rely on a radiologist's report. The quality of the information you gain will be based on the types of images that are performed of the tendon, the quality of the equipment performing the scan, and the radiologist's knowledge of foot and ankle anatomy, most particularly in tibialis posterior dysfunction. It is usually helpful to speak to the radiologist at the center where you will predominately have your studies performed. It is important for them to perform images in close sequence on the medial side of the foot in order to evaluate all aspects of the tibialis posterior tendon. You might even supply the radiologist with some of the relevant literature regarding this disorder. Reviewing the clinical findings with the radiologist may also help to educate them as to what to look for. Lastly, the podiatric physician should be skilled in interpreting MRIs of the lower extremity and not simply rely on a radiologist's report. The most useful MRI classification of a tibialis posterior dysfunction is that proposed by Conti et al.[13] (Table 1).

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Table 1

MRI CLASSIFICATION OF TIBIALIS POSTERIOR TENDON DEGENERATION[13]

Type IA - MRI:	few longitudinal splits no intra substance degeneration Clinical: short duration, minimal tenderness, swelling, no heel valgus
Type IB - MRI:	increased number of longitudinal splits increased tendon width Clinical: as with IA, but longer duration 6-12 months
Type II - MRI:	tendon narrowed long longitudinal splits intramural tendon degeneration Clinical: increased valgus 12-18 months duration
Type III - MRI:	diffuse tendon swelling uniform degeneration a few intact strands of tendon Clinical: minimal inversion strength marked heel valgus generally more than 2 years
Type IIIB - MRI:	complete rupture of tendon replacement by scar tissue Clinical: duration greater than $2\ ^1/_2$ years all signs and symptoms