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Peroneal Tendon Abnormalities on Routine Magnetic Resonance Imaging of the Foot and Ankle

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Abstract

Background: Abnormalities of the peroneal tendons can frequently be identified on routine MRI of the foot and ankle. Previous studies in the orthopedic literature have discussed the prevalence of abnormal MRI findings in asymptomatic patients, most notably with regards to the spine and shoulder. The purpose of this study was to determine the prevalence of abnormal findings of the peroneal tendons on MRI in asymptomatic individuals.

Methods: We retrospectively reviewed all foot and ankle MRIs from 2 independent time periods that were either performed or reviewed at our institution. Studies were excluded if performed on patients with documented inversion injuries, ankle sprains, or lateral ankle trauma. A total of 294 (of 617) MRIs were eligible for inclusion in this study. A single attending musculoskeletal radiologist reviewed each MRI. Pathologies of the peroneal tendons included tendinosis, tenosynovitis, acute tears, chronic tears, and tendon splits. Additionally, the primary pathology encountered on each MRI was noted. The mean age of the MRIs included in this study was 46.8 years (range 9-82) with 155 females and 139 males.

Results: The most commonly occurring primary pathology was Achilles tendinosis/tears (86), followed by posterior tibial tendon dysfunction (43). With regards to the peroneal tendons, 103 of the 294 (35%) MRIs demonstrated some pathology.

Conclusion: The results of this study demonstrated that a sizeable percentage of asymptomatic individuals could have peroneal tendon pathology on MRI of the foot and ankle. This study can have important clinical implications for when patients present with concerning MRI findings that do not correlate clinically. Physicians providing musculoskeletal care can counsel and reassure patients who present with peroneal pathology on MRI but an absence of clinical findings.

Level of Evidence: Level IV, case series.

Keywords: peroneal tendons, MRI, asymptomatic

Introduction

The peroneal tendons serve as the primary evertors of the foot as well as dynamic stabilizers of the ankle. Injuries to the peroneal tendons can be diagnosed through a detailed patient history, physical examination, as well as magnetic resonance imaging (MRI). Given the complexity and proximity of many soft tissue structures in the foot and ankle, MRI can be fraught with false positive and false negative results. The diagnosis and treatment of lateral ankle pathology, therefore, should not solely rely on an MRI examination. A multitude of studies have been published within other areas of orthopedic surgery detailing the high incidence of MRI abnormalities found in asymptomatic individuals. This has been found to be true in the shoulder with regard to rotator cuff pathology, the hip with regard to labral pathology, and the cervical and lumbar spine.[5,9,12,14,16]

Prior studies have reported the accuracy of MRI in diagnosing peroneal pathology ranging from 56% to 100%.[7,11] Kuwada reported a 57% sensitivity of MRI and found peroneal injuries to be the most challenging pathologic entity to identify within the foot and ankle,[6] whereas Park et al reviewed 97 MRIs and compared these results with surgical findings in symptomatic patients and concluded that MRI is specific but not sensitive when it comes to peroneal

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pathology.[10] There are, however, numerous MRI-reported pathologies of the peroneal tendons in patients who are completely asymptomatic in this area. This can be a result of truly asymptomatic pathology within the tendon, or the false appearance of pathology in a normal tendon due to the magic angle effect (MAE).

Saxena et al reported that approximately 33% of asymptomatic individuals demonstrated lateral ankle pathology on MRI but they only identified tears within the lateral ankle and they included the anterior talofibular ligament (ATFL) and the calcaneofibular ligament (CFL), in addition to the peroneal tendons.[13] They did not mention additional types of pathology nor did they focus their study solely on the peroneal tendons. Galli et al recently published a study that focused on the correlation between certain anatomic variants and peroneal pathologies on MRI of asymptomatic lateral ankles. The breakdown of peroneal pathology was simply tear versus tendinopathy, and they did not comment on the location of pathology along the peroneal tendons.[4]

MAE is a well-documented entity of MRI that is particularly relevant when imaging tissues composed of well-ordered collagen fibers, such as tendons, using sequences with short echo time.[1-3] It is our belief that the MAE plays a key role in the abnormally high rate of false positive findings with regards to the peroneal tendons, specifically as they course below the lateral malleolus.

Although there have been studies published on peroneal tendon pathology in asymptomatic individuals, there have not been any that, to our knowledge, critically examined the different pathologies most frequently encountered, as well as the location of pathology along the course of the tendons as they cross the ankle joint into the foot. It is our belief that evaluating the location of peroneal pathology on MRI is important because of the MAE.

Methods

After obtaining institutional review board (IRB) approval, a retrospective review was undertaken on all ankle MRIs from 2 independent time periods. The MRIs were either performed at imaging centers affiliated with a single large academic medical institution or were performed elsewhere and the interpretations were confirmed by a fellowship-trained musculoskeletal radiologist at our academic institution. All MRI examinations were acquired at 1.5 Tesla using a dedicated ankle/foot receiver coil. The protocol included T2-weighted fat suppressed sequences (TR [time to response] = maximum, TE [time to echo] = 60-80 milliseconds) in coronal, conventional axial and sagittal planes along with a STIR (short tau inversion recovery, TR = maximum, TE = 25-40, time to inversion [TI] = 120-150 milliseconds) sequence in the sagittal plane. Non–fat suppressed short TE sequences were acquired in 2 planes for assessment of osseous and articular architecture. Intravenous contrast and intra-articular contrast protocols were not used in our study group. Submitted prescriptions for each MRI outlined the suspected diagnosis for which the MRI was ordered. Additionally, all patients were clinically evaluated by a fellowship-trained foot and ankle orthopedic surgeon who evaluated the peroneal tendons in each patient after the MRI had been completed. All office notes were available and were reviewed and correlated with MRI findings. Patients were deemed asymptomatic if they did not have any lateral swelling or ecchymosis, did not have any tenderness to palpation over the peroneal tendons, did not have any pain or weakness with resisted eversion of the foot, or had any evidence of peroneal tendon subluxation. Any prescriptions or office notes that included "inversion injury," "ankle sprain," "trauma to lateral ankle," or "peroneal tendon" in the diagnosis or history were excluded from the study. We felt that any mention of these terms in the diagnosis or patient history would preclude these patients from being considered truly asymptomatic as the peroneal tendons are frequently injured during this injury mechanism. All other diagnoses/indications were included. MRIs were excluded if the lateral ankle ligaments and tendons were not well visualized. MRIs were also excluded from the study if they were obtained more than 6 months from the date of the physical examination/office visit.

A total of 617 MRIs of the foot and ankle were eligible for review from 2 independent time periods. Of these, 411 were obtained within 6 months of a documented clinical examination. Office notes for all patients were reviewed. One hundred seventeen studies were excluded because of documented lateral ankle symptoms or evidence of peroneal pathology on their clinical examinations performed by a fellowship-trained foot and ankle orthopedic surgeon. This left 294 MRIs eligible for inclusion in the study. There were 155 female patients and 139 male patients with an average age of 46.8 (range 9-82) years.

All MRIs that met the inclusion criteria were made available for further review. The primary pathology was noted for each MRI reviewed. Additionally, it was noted if any peroneal pathology was visualized. We further subdivided this by tendon involvement: peroneus longus, peroneus brevis, or both. We also determined whether the pathology occurred supramalleolar (above the lateral malleolus), retromalleolar (posterior to the lateral malleolus), or inframalleolar (distal to the inferior-most aspect of the lateral malleolus). Pathologies included split tears, acute/chronic ruptures, tendinosis, tendonitis/tenosynovitis, or "other" if the pathology encountered did not fall into a specific category. If there were multiple pathologies noted for a single MRI, each was counted separately.

Statistical analysis was carried out using Fisher exact tests through GraphPad Software, Inc (La Jolla, CA).

Table 1. Incidence of Pathology Based on Tendon.

Tendon involvement	n (%)
Longus	35 (34.0)
Brevis	33 (32.0)
Both[a]	35 (34.0)

[a]"Both" refers to MRIs in which both the peroneus longus and brevis demonstrated pathology.

Results

Of the 294 studies evaluated, 103 (35%) demonstrated peroneal pathology. With regards to gender, there was no statistically significant relationship ($P = .1792$). However, there was a statistically significant relationship between peroneal pathology and age. Those individuals whose MRI demonstrated some form of peroneal pathology had an average age of 52.2 ± 12.1 years, and those individuals without peroneal pathology had an average age of 43.8 ± 17.1 years ($P < .001$).

Of the 103 MRIs that demonstrated peroneal pathology, 35 (34%) involved peroneus longus, 33 (32%) involved peroneus brevis, and 35 (34%) involved both longus and brevis (Table 1). With regard to location, 8 (7.8%) were supramalleolar, 29 (28.2%) were retromalleolar, and 66 (64.1%) were inframalleolar ($P < .001$) (Table 2). With regard to specific pathologies, 55 (53.4%) showed evidence of tendinosis, 46 (44.7%) demonstrated a split tear of one or both of the peroneal tendons, 34 (33%) demonstrated findings consistent with tendinitis/tenosynovitis, 1 revealed a peroneal rupture, and 1 was interpreted as pseudosubluxation of the peroneal tendons (Table 3).

We also looked at the primary pathology that was noted for each MRI. The most common was Achilles tendinosis/tears (86 patients, 29.3%), followed by posterior tibial tendon dysfunction (43 patients, 14.6%), stress fracture (30 patients, 10.2%), osteochondral lesions (28 patients, 9.5%), and plantar fasciitis (25 patients, 8.5%). Eleven of the MRIs were interpreted as normal, with no distinct pathology seen. A full breakdown of pathologies can be seen in Table 4. There were no statistically significant relationships detected among the various primary pathologies with regards to peroneal pathology.

Discussion

Given the anatomic complexity of the foot and ankle, MRI can be fraught with false positive and false negative results. This has been shown in other orthopedic subspecialties.[5,9,12,14,16] Therefore, diagnosis and treatment of foot and ankle pathology should not rely solely on MRI findings. Such findings should be used to supplement the information obtained from the history and physical examination in order to make a diagnosis and devise a treatment plan.

Table 2. Location of Pathology Along the Peroneal Tendons.[a]

Location of pathology	n (%)
Inframalleolar	66 (64.1)
Retromalleolar	29 (28.1)
Supramalleolar	8 (7.8)

[a]Inframalleolar refers to any pathology distal to the inferior tip of the lateral malleolus. Retromalleolar refers to pathology immediately posterior to distal fibula in fibular groove. Supramalleolar refers to pathology occurring above the level of the fibular groove.

Table 3. Breakdown to the Different Peroneal Pathologies Encountered.

Peroneal pathology	n (%)
Tendinosis	55 (53.4)
Split tear	46 (44.7)
Tendonitis/tenosynovitis	34 (33.0)
Acute rupture	1 (1.0)
Pseudosubluxation	1 (1.0)

Table 4. Breakdown of Primary Pathology Noted on MRIs in Which Peroneal Pathology Was Also Seen.

Primary pathology	n (%)
Achilles tears/tendinopathy	86 (29.3)
Posterior tibial tendinopathy	43 (14.6)
Stress fracture	30 (10.2)
Osteochondral lesions	28 (9.5)
Plantar fasciitis	25 (8.5)
Arthritis	14 (4.8)
Normal study	11 (3.7)
Peroneal tendinopathy	8 (2.7)
Ligament sprain/tear	8 (2.7)
Mass/tumor	7 (2.4)
Contusion	6 (2.0)
Bursitis/synovitis	6 (2.0)
Other[a]	22 (7.5)

[a]"Other" includes tarsal coalitions, avascular necrosis, accessory ossification centers, osteomyelitis, impingement, soft tissue ulcers, Charcot arthropathy, and a loose body.

Previous studies have reported a wide variation with regards to the accuracy of MRI in diagnosing peroneal pathology. Lamm et al reported a sensitivity of 83% and specificity of 75% when comparing MRI and intraoperative findings in patients with symptomatic pathology within their peroneus brevis tendons.[7] Rademaker et al reported 100% accuracy of MRI in diagnosing ruptures of the peroneus longus in the plantar midfoot but did not evaluate the tendon at the level of the ankle, nor for evidence of additional pathologies.[11] Looking at asymptomatic individuals, Saxena et al found that 33% will have some abnormality

with regards to the lateral ankle soft tissue structures, including the ATFL, CFL, and the peroneal tendons on MRI.[13] Their study focused solely on tears of these structures and did not evaluate the prevalence of other pathologies assessed in the current study. Our study focused on the peroneal tendons and looked at a spectrum of pathologies. We found a 35% rate of abnormal findings in the peroneal tendons in asymptomatic individuals. The most commonly encountered abnormal findings included tendinosis (53%), tears (44%), and tendinitis/tenosynovitis (33%).

An explanation for this high percentage of abnormal findings in asymptomatic patients may be the MAE. It is a well-documented MRI artifact that occurs on sequences with a short echo time (<32 milliseconds; T1-weighted sequences, PD sequences, gradient echo sequences).[2] It is particularly relevant in tissues that are composed of well-ordered collagen fibers, such as tendons, ligaments, and cartilage. It is confined to regions of tightly bound collagen at 54.74 degrees from the magnetic field (B0), and appears hyperintense, thus potentially being mistaken for tendinopathy.[1,3] It is a commonly encountered phenomenon occurring in tendons or ligaments undergoing a tortuous course such as the proximal portion of the PCL, the peroneal tendons as they course around the lateral malleolus, the supraspinatus tendon, the triangular fibrocartilage complex (if the patients is imaged with the arm elevated), and the patellar tendon at its tibial insertion.

When evaluating MR images for tendon pathology, we looked for changes in signal intensity, morphology, and associated findings in tendon sheaths or bone marrow. The MAE can create a "pseudoappearance" of torn or diseased structures, leading to false positive results. The peroneal tendons have been recognized as particularly susceptible to this phenomenon.[8,15] Mengiardi et al showed the MAE to be present in 100% of peroneus brevis tendons and 77% of peroneus longus tendons when patients were scanned in the supine position.[8] For the peroneus brevis tendon, the effect was most pronounced between the inferior tip of the lateral malleolus and the base of the fifth metatarsal. For the peroneus longus, it was most commonly seen between the peroneal trochlea and lateral edge of the cuboid. Mengiardi et al suggested scanning patients in the prone position to reduce the MAE.[8] However, all of the MRIs that comprised our study were performed in the supine position. We found a significantly greater proportion of pathology in the inframalleolar region, which we defined as anything distal to the inferior tip of the lateral malleolus ($P < .001$). This may indicate that a significant proportion of peroneal pathology seen on MRIs of asymptomatic patients does not represent true pathology, particularly when such "pathology" occurs distal to the inferior tip of the lateral malleolus.

This study does have some limitations. Although MRI can be quite sensitive in detecting injuries to the peroneal tendons, operative findings remain the gold standard. However, operative treatment or investigation was not warranted in our asymptomatic population. Our study was also a retrospective review based on office notes, although a prospective study is currently being formulated at our institution.

In conclusion, orthopedic surgeons and any other physicians who provide musculoskeletal care should be aware of the potential pitfalls inherent with MRI. Abnormalities that may be present on MRI must always be correlated with a comprehensive history and physical examination. In the absence of supportive physical examination findings, physicians can provide reassurance to patients who present with MRI findings of peroneal pathology, particularly when it occurs in an inframalleolar location. As postulated by Mengiardi et al, scanning patients in the prone position can help to reduce the MAE. In addition to patient positioning, MRI protocols that employ sequences with longer echo times and dedicated foot/ankle receiver coils may help to mitigate the MAE.

Declaration of Conflicting Interests

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References

1. Berendson H. Nuclear magnetic resonance study of collagen hydration. *J Chem Phys*. 1962;36:3297-3305.
2. Erickson SJ, Prost RW, Timins ME. The "magic angle" effect: background physics and clinical relevance. *Radiology*. 1993;188(1):23-25.
3. Fullerton GD, Cameron IL, Ord VA. Orientation of tendons in the magnetic field and its effect on T2 relaxation times. *Radiology*. 1985;155(2):433-435.
4. Galli MM, Protzman NM, Mandelker EM, et al. An examination of anatomic variants and incidental peroneal tendon pathologic features: a comprehensive MRI review of asymptomatic lateral ankles. *J Foot Ankle Surg*. 2015;54(2):164-172.
5. Jost B, Zumstein M, Pfirrmann CW, et al. MRI findings in throwing shoulders: abnormalities in professional handball players. *Clin Orthop Relat Res*. 2005;434:130-137.
6. Kuwada GT. Surgical correlation of preoperative MRI findings of trauma to tendons and ligaments of the foot and ankle. *J Am Podiatr Med Assoc*. 2008;98:370-373.
7. Lamm BM, Myers DT, Dombek M, et al. Magnetic resonance imaging and surgical correlation of peroneus brevis tears. *J Foot Ankle Surg*. 2004;43:30-36.
8. Mengiardi B, Pfirrmann CW, Schottle PB, et al. Magic angle effect in MR imaging of ankle tendons: influence of foot positioning on prevalence and site in asymptomatic subjects and cadaveric tendons. *Eur Radiol*. 2006;16(10):2197-2206.

9. Moosmayer S, Tariq R, Stiris MG, et al. MRI of symptomatic and asymptomatic full-thickness rotator cuff tears: a comparison of findings in 100 subjects. *Acta Orthop*. 2010;81(3):361-366.
10. Park HJ, Lee SY, Park NH, et al. Accuracy of MR findings in characterizing peroneal tendon disorders in comparison with surgery. *Acta Radiol*. 2012;53:795-801.
11. Rademaker J, Rosenberg ZS, Delfaut EM, et al. Tears of the peroneus longus tendon: MR imaging features in nine patients. *Radiology*. 2000;214:700-704.
12. Register B, Pennock AT, Ho CP, et al. Prevalence of abnormal hip findings in asymptomatic participants: a prospective, blinded study. *Am J Sports Med*. 2012;40(12):2720-2724.
13. Saxena A, Luhadiya A, Ewen B, et al. Magnetic resonance imaging and incidental findings of lateral ankle pathologic features with asymptomatic ankles. *J Foot Ankle Surg*. 2011;50(4):413-415.
14. Siivola SM, Levoska S, Tervonen O, et al. MRI changes of cervical spine in asymptomatic and symptomatic young adults. *Eur Spine J*. 2002;11(4):358-363.
15. Wang XT, Rosenberg ZS, Mechlin MB, et al. Normal variants and diseases of the peroneal tendons and superior peroneal retinaculum: MR imaging features. *Radiographics*. 2005;25:587-602.
16. Weishaupt D, Zanetti M, Hodler J, et al. MR imaging of the lumbar spine: prevalence of intervertebral disk extrusion and sequestration, nerve root compression, end plate abnormalities, and osteoarthritis of the facet joints in asymptomatic volunteers. *Radiology*. 1998;209(3):661-666.