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Research article

Posterior tibial tendon dysfunction: Clinical and magnetic resonance imaging findings having histology as reference standard

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A R T I C L E I N F O

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A B S T R A C T

Objective: To investigate the correlation between MRI, clinical tests, histopathologic features of posterior tibial tendon (PTT) dysfunction in patients with acquired adult flatfoot deformity surgically treated with medializing calcaneal osteotomy and flexor digitorum longus tendon transposition.

Materials and methods: Nineteen patients (11 females; age: 46 ± 15 year, range 18–75) were pre-operatively evaluated using the single heel rise (HR) and the first metatarsal rise (FMR) sign tests. Two reviewers graded the PTT tears on a I–III scale and measured the hindfoot valgus angle on the pre-operative MRI of the ankle. The specimens of the removed portion of PTT were histologically analysed by two pathologists using the Bonar and Movin score. Linear regression, Spearman's rank-order, and intraclass correlation coefficient (ICC) statistics were used.

Results: ICC for MRI was excellent (0.952). Correlation between FMR and HR tests was at limit of significance ($r = 0.454$; $P = 0.051$). The HR and FMR tests were significantly correlated to the Movin score ($r = 0.581$; $P = 0.009$ and $r = 0.538$; $P = 0.018$, respectively) and were not significantly correlated to the Bonar score (both with a $r = 0.424$; $P = 0.070$). PTT tendinopathy grading at MRI was significantly correlated to the FMR test ($p = 0.041$) but not to the hindfoot valgus angle ($p = 0.496$), the HR test ($p = 0.943$), the Bonar score ($p = 0.937$), and the Movin score ($p = 0.436$). The hindfoot angle was not correlated to any of the other variables ($p > 0.264$).

Conclusion: For PTT dysfunction, there is high correlation between HR and FMR test and histology evaluated using the Movin score, while no correlation was seen for the Bonar score. Semiquantitative grading of PTT dysfunction at MRI only correlates to the FMR and not to histology. The hindfoot valgus angle is not correlated to any of the considered variables.

1. Introduction

The posterior tibial tendon (PTT) plays a crucial role in supporting the medial longitudinal arch of the foot and in stabilizing the hindfoot against valgus deformity [1]. PTT dysfunction is a common condition characterized by a valgus hindfoot, flattening of the medial longitudinal arch of the foot, and abduction of the forefoot [2]. Actually, this disorder is a more complex and multifactorial condition, involving all the posteromedial soft tissues such as the spring and deltoid ligaments as well as the PTT, thus leading to the acquired adult flatfoot deformity (AAFD) [3]. Patients commonly show swelling along the PTT accompanied by a gradual onset of posteromedial hindfoot pain aggravated by standing and walking [2,4]. They may also present lateral hindfoot pain due to lateral impingement of the fibula on the calcaneus [5]. This disabling disorder is often overlooked, not well managed and identified only at later stages [6].

Clinically, one of the most common tests to assess the PTT functionality is the single heel rise (HR) test [4]. An abnormal HR test is observed when the patient is unable to perform a heel rise or performs the heel rise with hindfoot eversion, failing to invert on rising [4].

Abbreviations: PTT, posterior tibial tendon; AAFD, acquired adult flatfoot deformity; HR, heel rise; FMR, first metatarsal rise; MRI, magnetic resonance imaging; FDLT, flexor digitorum longus tendon; TR, repetition time; TE, echo time; STIR, sagittal short time inversion recovery

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However, previous studies that sought to clarify the reliability of this test in the assessment of PTT dysfunction have achieved controversial results [7–9]. Another useful test is the first metatarsal rise (FMR) sign test, in which the investigator externally rotates the shin of the affected foot with one hand and the head of the first metatarsal remains on the ground in normal PTT function, whereas it lifts off the floor in the case of PTT dysfunction [10].

Magnetic resonance imaging (MRI) is a reliable tool to identify the different patterns of presentation of PTT dysfunction, namely degenerative tendinopathy, tenosynovitis, and partial or complete tear [11,12]. MRI may also help identifying bone malalignments, such as a valgus hindfoot that may lead to painful lateral hindfoot impingement [13].

Treatment of PTT dysfunction depends on the severity of the condition and, as pathology progresses, conservative therapies become ineffective with the need of more invasive surgical treatments [14]. The early stage PTT dysfunction is generally treated with non-operative approaches, including orthosis, shoe modifications, and physical therapies [15,16]; surgical approach is adopted when conservative treatments result unsuccessful and in advanced stage disease [14,17]. The surgical treatment of early stage PTT dysfunction usually consists of medializing calcaneal osteotomy and flexor digitorum longus tendon (FDLT) transposition, which demonstrated to lead to pain relief and function improvement [18–20]. In advanced stages, surgical treatment may include either subtalar, double, or triple arthrodesis [14]. Thus, early diagnosis and correct staging of PTT dysfunction is crucial to properly choose the treatment strategy and improve the clinical outcome of patients. However, there are no previous studies focusing on the importance of reporting pre-operative MRI features such as PTT tendinopathy grading and hinfoot valgus angle comparing these findings with clinical and histopathologic data.

The aim of our study was to investigate the correlation between MRI, clinical tests, and histopathologic features of PTT dysfunction in patients with AAFD surgically treated with medializing calcaneal osteotomy and FDLT transposition.

2. Materials and methods

2.1. Patients

Institutional review board approval was obtained and patients' informed consent was waived for this retrospective study.

All patients included in this study had PTT dysfunction and AAFD unresponsive to at least six months of conservative treatments and performed a pre-operative MRI of the ankle. Then, all patients were surgically treated using medializing calcaneal osteotomy and FDLT transposition technique. Before surgery, they were thoroughly clinically evaluated, including the HR and FMR tests. After surgery, the specimens of the removed portion of PTT were histologically analysed by two different anatomo-pathologists.

The following exclusion criteria were applied: clinical tests not performed before surgery; age below 18 years; previous surgical treatments of ankle or foot; diabetes mellitus; chronic inflammatory, reumathologic, and immune-mediated diseases (i.e., rheumatoid arthritis, systemic lupus erythematosus); previous infectious arthritis of ankle or foot.

A total of 27 patients with PTT dysfunction and AAFD were evaluated for potential inclusion in this study. Among them, 19 patients (11 females, 8 males; age: 46 ± 15, range 18–75) performed a MRI scan of the ankle up to one month before surgery and were finally included in the study.

2.2. MRI protocol and images interpretation

All MRI scans were performed at 1.5 T (MAGNETOM Avanto, Siemens Medical Solution, Erlangen, Germany, gradient strength 45 mT/m, slew rate 200 T/m/ms; MAGNETOM Espree, Siemens Medical Solution, Erlangen, Germany, gradient strength 33 mT/m, slew rate 170 T/m/ms) using a dedicated extremity coil. The following sequences were performed: sagittal T1-weighted turbo spin-echo [repetition time (TR)/echo time (TE) of 500/9.2 ms, slice thickness 3 mm], sagittal short time inversion recovery (STIR) [TR/TE 3990/29 ms, inversion time 160 ms, slice thickness 3 mm], axial T1-weighted turbo spin-echo [TR/TE 500/9.2 ms, slice thickness 3 mm], axial proton density-weighted fat-saturated [TR/TE 4120/32 ms, slice thickness 3 mm], coronal proton density-weighted fat-saturated [TR/TE 4120/32 ms, slice thickness 3 mm], coronal T2-weighted turbo spin-echo [TR/TE 4500/81 ms, slice thickness 3 mm].

A radiologist and a radiology resident with 10 and 4 years' experience in musculoskeletal imaging, respectively, independently reviewed the MRI scans. They were blinded about the clinical severity of PTT dysfunction. PTT tears were graded on a I–III scale on the basis of previously described classification systems [21] as follows: grade Ia, thickened PTT with no or minimal amount of longitudinal splits; grade Ib, thickened PTT with a large amount of longitudinal splits; grade II, attenuated PTT (equal or smaller than the adjacent FDLT); grade III, complete PTT tear. The MRI hindfoot valgus angle was measured, as previously described by Donovan et al. [13], on the most posterior coronal image including tibia and calcaneus by intersecting a line along the long axis of the tibia and a line along the medial wall of the calcaneus. Hindfoot valgus on MRI was defined as: (i) normal, with a tibiocalcaneal angle $\leq 6°$; (ii) mild, with an angle 7°–16°; (iii) moderate, 17°–26°; (iv) severe, with an angle $> 26°$. The mean value of the measures taken by the two observers was used in the analysis.

2.3. Clinical tests

One orthopaedic surgeon with 15 years' experience in foot and ankle disorders clinically evaluated all patients using the HR and FMR tests.

During the HR test, the patients were requested to perform a heel rise task while keeping the contralateral foot lifted off the ground [4]. The orthopaedic surgeon assigned three different scores as follows: (i) 0, if the patient was able to perform the heel rise; (ii) 1, if the patient experienced difficulty rising onto the forefoot due to pain or performed the heel rise with hind foot eversion (failing to invert on rising); (iii) 2, if the patient was not able to perform a heel rise [14].

During the FMR test, the patients were asked to stand full weight bearing on both feet. The orthopaedic surgeon held the leg of the affected side with one hand and externally rotated it to bring the heel into a varus position [10]. The FMR test was defined negative if the head of the first metatarsal remained on the ground, whereas it was positive if the first metatarsal lifted off the floor [10].

2.4. Surgical intervention

All patients were surgically treated using medializing calcaneal osteotomy and FDLT transposition technique. During surgery, the patient was placed supine on the operating table and a sandbag positioned under the ipsilateral hip to rotate the limb internally. A lateral access was performed by an oblique incision approximately 2 cm distal and behind the lateral malleolus, avoiding the sural nerve, to allow the lateral aspect of the calcaneus to be exposed for the osteotomy. The osteotomy was made at an angle of approximately 45 ° to the sole of the foot and the distal bone segment was displaced medially for 1 cm and held by two cannulated, partially-threaded, 6.5 mm cancellous screws or by placing a 2 mm k-wire. The lateral wound was closed and the sandbag removed. A medial incision was then made along the line of the PTT and extended distally to expose the FDLT. In all cases, macroscopic PTT changes were identified and areas of degeneration were excised. The FDLT was then followed up to the knot of Henry and divided distally. A 4.5 mm drill hole was made from the dorsal to plantar