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Diagnostic Characteristics of Standard Radiographs and Magnetic Resonance Imaging of Ruptures of the Tibialis Posterior Tendon

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ABSTRACT

The present study aimed to diagnose complete rupture (CR) and longitudinal rupture (LR) of the posterior tibial tendon (PTT) from the magnetic resonance imaging findings in patients with PTT dysfunction and to analyze and compare the radiographs from each group to identify radiographic indicators related to the progression of PTT injury that would allow the radiographic diagnosis of CR. We evaluated 32 feet in 27 patients with PTT dysfunction (mean age 66.5, range 49 to 82, years). Radiographs were used to acquire weightbearing anteroposterior images of the foot, which were used to measure the talonavicular coverage angle. Lateral images of the foot were also acquired with the patients in the standing position. These were used to measure the lateral talometatarsal angle, calcaneal pitch angle, and medial cuneiform–fifth metatarsal height. From the axial MRI findings, the patients were divided into a CR group and an LR group, and the radiographic attributes of the CR group were analyzed. Of the 32 feet in 27 patients, 12 feet (37.5%) in 11 patients displayed CR and 20 feet (62.5%) in 18 patients displayed LR. The talonavicular coverage angle was 48.3° ± 17.3° in the CR group and 33.6° ± 13.6° in the LR group ($p = .012$), and the talometatarsal angle was −28.8° ± 22.5° in the CR group and −25.4° ± 14.4° in the LR group ($p = .596$). The calcaneal pitch angle was 10.4° ± 6.7° in the CR group and 10.2° ± 8.0° in the LR group ($p = .935$). Finally, the medial cuneiform–fifth metatarsal height was −4.2 ± 7.1 mm in the CR group and 2.1 ± 4.7 mm in the LR group ($p = .005$). When a medial cuneiform–fifth metatarsal height of ≤0 mm or talonavicular coverage angle of ≥50° was used as the diagnostic criterion for CR on weightbearing radiographs, the sensitivity was 71.4%, specificity 88.9%, and diagnostic accuracy 81.3%; hence, we believe these to be satisfactory diagnostic criteria for CR.

Posterior tibial tendon dysfunction (PTTD) is a cause of flat feet in adults that occurs when posterior tibial tendon (PTT) function is impaired. The PTT, along with the spring ligament, which supports the head of the talus from the inferomedial side, contributes to the maintenance of the medial longitudinal arch of the foot. The PTT can become degenerated or inflamed in response to aging (1), ischemia (2), repeated mild injuries (3), and other factors, resulting in stretching and tearing of the tendon and reduced function (4–6). Consequently, the load on the medial longitudinal arch, deltoid ligament, spring ligament, distal cuneonavicular joint capsule, and other structures is increased (7,8), and the arch structure gradually ruptures, causing flatfoot.

In patients with PTTD, the PTT initially manifests with inflammation or edema; however, as it progresses, a gradual longitudinal rupture occurs in the direction of the tendon, which eventually ruptures completely, breaking the continuity of the PTT (9). Patients with complete rupture will have more severe deformities than patients in whom the continuity of the PTT has been preserved. Also, it is believed that excessive pressure is placed on the distal talonavicular and distal talocalcaneal joints. When treating this condition, it is important to determine whether the rupture is longitudinal or complete (10). To date, however, almost no reports have been published of comparative studies between the conditions of, and diagnostic methods for, identifying a longitudinal and complete rupture (LR and CR, respectively).

Plain radiographs and magnetic resonance imaging (MRI) scans are the conventional imaging modalities for PTTD. Plain radiographs

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are a familiar and rapid diagnostic method. However, no diagnostic criteria have been established for identifying PTTD on plain radiographs. MRI is capable of visualizing edema surrounding the PTT, deformations, LRs, and CRs of the PTT (10,11). However, MRI scans are expensive, and the images can often require some time to become available. Therefore, if the MRI evaluation findings of the extent of a PTT injury could be correlated with the plain radiographic signs of flatfoot, it is possible that plain radiographs could be used to diagnose complete PTT rupture at an initial visit, without MRI, and perhaps aid in the treatment.

With our interest in comparing the MRI scans and radiographic findings from patients diagnosed with complete or longitudinal PTT rupture, we undertook a retrospective cohort study to identify the differences between patients with CR and LR of the PTT. Additionally, using a radiographic measurement method that strongly correlated with the diagnostic criteria for CR, we aimed to measure the association between the standard radiographic findings and CR of the PTT.

Patients and Methods

The institutional review board of the Kyoto Prefectural University of Medicine approved the present retrospective cohort study (approval no. ERB-C-324). Patients with PTTD were identified by searching the Kyoto Prefectural University of Medicine database for the "International Classification of Disease, 9th revision" (World Health Organization, Geneva, Switzerland) diagnosis code 727.60 (PTTD), who had been evaluated and treated from April 2008 to April 2014. The potentially eligible patients with the "International Classification of Disease, 9th revision" code of 727.60 were all identified. Next, the medical records were abstracted by 2 of us (K.I., M.M.), resulting in the identification of 32 feet in 27 patients that fit our inclusion criteria. We evaluated 32 feet in 27 patients who had painful PTTD (5 males [18.52%] and 22 females [81.48%]; 17 right feet [53.1%] and 15 left feet [46.9%]). The stage of PTTD was categorized using the Myerson classification (12), which revealed 28 feet (87.5%) with stage II and 4 (12.5%) with stage III. All the patients analyzed in the present investigation underwent standard weightbearing radiographic and MRI assessments of their symptomatic feet. However, only 28 feet (87.5%) in 23 patients (85%) actually underwent surgical treatment; thus, we did not use operative inspection of the tendon as the reference standard assessment for LR or CR of the PTT. Instead, we used the MRI findings as the reference standard for the diagnosis of rupture of the PTT and compared the diagnostic operational characteristics of the various standard radiographic findings with the MRI findings.

Radiographic Evaluation

For each participant, weightbearing anteroposterior and lateral radiographs were obtained in a standardized manner, with a cassette placed directly adjacent to the foot. The talonavicular coverage angle (TNC), as described by Sangeorzan et al (13), was measured on the anteroposterior images (Fig. 1). The lateral talometatarsal angle (LTM) (14), calcaneal pitch (CP) (15), and medial cuneiform–fifth metatarsal height (C5MTH) (16–18) were measured (Fig. 2) using the lateral projection radiographic images. Two foot and ankle surgeons (K.I., S.O.) performed the measurements using the clinic's digital radiographic image viewer (iSite, Philips, Best, Netherlands).

MRI Evaluation

MRI scans were obtained for all patients using a 3.0-T MRI system (Achieva 3.0 T X-series; Philips Healthcare, Best, Netherlands) with an 8-channel knee coil. Images were taken under proton density high-contrast conditions (fast spin echo, repetition time 1956 ms, excitation time 18 ms, and 3-mm thickness). Horizontal cross-sections were evaluated by 3 of us (K.I., M.K., Y.H.). The MRI findings were categorized according to the state of the PTT, using the classification from Conti et al (10). Specifically, grade 1 involved 1 or 2 fine longitudinal splits in the tendon (Fig. 3*A*); grade 2, wider longitudinal splits and intramural degeneration (Fig. 3*B*); and grade 3, the presence of diffuse swelling and uniform degeneration, with replacement of most of the tendon by scar tissue (Fig. 3*C*). The grade 3 findings are consistent with CR. Using the MRI findings, patients classified as having Conti grade 1 or 2 were included in the LR group and those classified as having Conti grade 3 and those who required surgical PTT repair were included in the CR group. The latter group were treated by 2 of us (K.I., M.M.).

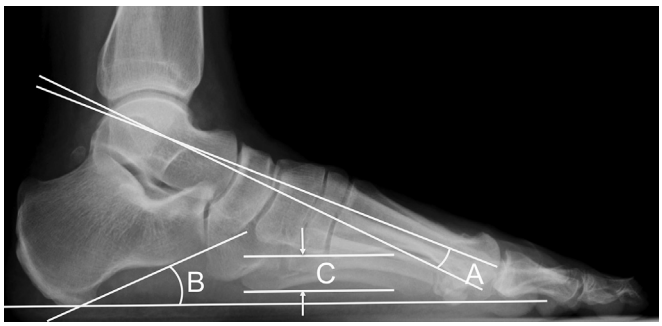

Fig. 1. Lateral radiograph showing measurements of A, talo-first metatarsal angle; B, calcaneal pitch angle; and C, medial cuneiform–fifth metatarsal height.

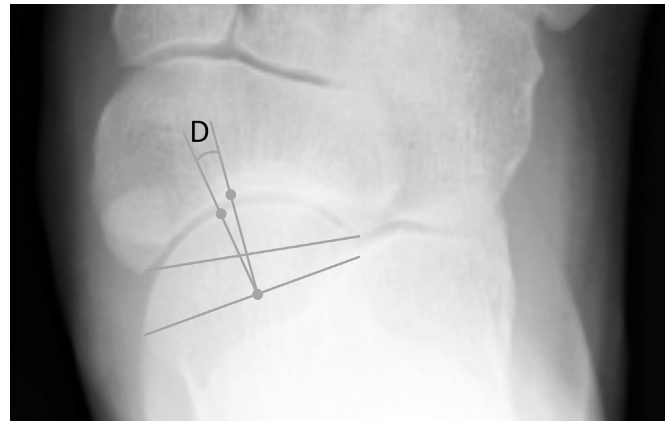

Fig. 2. Anteroposterior radiograph showing measurements of D, the talonavicular coverage angle.

Statistical Analysis

Statistical analyses of the various radiographic parameters for the LR and CR groups (categorized using the MRI scans) were performed using Student's t test (IBM SPSS Statistics for Windows, version 20.0, IBM Corp., Armonk, NY). The analyses were performed by 4 of us (K.I., S.O., Y.H.). The level of statistical significance was set at the 5% ($p \leq .05$) level. Furthermore, to determine the optimal TNC cutoff value to differentiate feet with CR of the PTT from feet with LR of the PTT, a receiver operating characteristic curve was created, and the area under that curve was calculated. The area under the curve was 0.724 for the receiver operating characteristic curve calculated from the sensitivity and 1 – specificity, with a flatfoot defined as a TNC of $\geq 50^\circ$. With a cutoff TNC of 50°, the sensitivity was 0.700 and the specificity was 0.905 for CR of the PTT. Also, the distance of C5MTH had a problem of scale on the radiographs; thus, we decided the C5MTH should be set to 0 mm as the most suitable cutoff value. Cases in which the C5MTH was ≤ 0 mm or the TNC was $\geq 50^\circ$ were considered to have CR of the PTT, and the data were analyzed using Fisher's exact test. After testing for significance, the sensitivity, specificity, and diagnostic accuracy were calculated for patients with a C5MTH of ≤ 0 mm or TNC of $\geq 50^\circ$ diagnosed with CR of PTT.

Results

Overall, PTT ruptures were present in 11 of the 19,904 patients (0.06%) who had visited our orthopedic department from April 1, 2008 to March 31, 2014. CRs were present in 12 feet (37.5%) in 11 patients (37.9%), including 1 male (9.1%) and 10 females (90.9%). These patients had a mean age of 66.8 (range 50 to 78) years. LRs were present in 20 feet (62.5%) in 18 patients (62.1%), including 4 males (22.2%) and 14 females (77.8%), with a mean age of 66.3 (range 49 to 82) years (Table 1). In those with CR and LR, the TNC was $48.3^\circ \pm 17.3^\circ$ and $33.6^\circ \pm 13.6^\circ$, respectively ($p = .012$). The LTM was $-28.8^\circ \pm 22.5^\circ$ in the CR group and $-25.4^\circ \pm 14.4^\circ$ ($p = .596$) in the LR group. The CP was $10.4^\circ \pm 6.7^\circ$ in the CR group and $10.2^\circ \pm 8.0^\circ$ ($p = .935$) in the LR group. Finally, the C5MTH was -4.2 ± 7.1 mm in the CR group and 2.1 ± 4.7 mm in the LR group ($p = .005$; Table 1). The C5MTH was significantly lower statistically in the CR group and the TNC was significantly greater. We defined a C5MTH of ≤ 0 mm and a TNC of $\geq 50^\circ$ as diagnostic for CR, and we used Fisher's exact test to analyze the data. A significant difference of $p = .0008$, with an $\varphi = 0.618$, was