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The value of the peroneus brevis tendon cross-sectional area in early diagnosing of peroneus brevis tendinitis

The peroneus brevis tendon cross-sectional area

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Abstract

A thickened peroneus brevis tendon has been considered to be an important morphologic parameter of peroneus brevis tendinitis (PBT). Previous researchers have found that the peroneus brevis tendon thickness (PBTT) is correlated with inflammation of the peroneus brevis tendon. However, inflammatory hypertrophic change is different from simple thickness. Thus, we devised the peroneus brevis tendon cross-sectional area (PBTCSA) as a new diagnostic parameter to analyze the hypertrophy of the whole PBT. We assumed that the PBTCSA is a major morphologic parameter useful for early PBT diagnosis. Peroneus brevis tendon images were collected from 22 patients with PBT and from 22 normal subjects who underwent ankle-magnetic resonance imaging and revealed no evidence of PBT. The T1-weighted axial ankle-magnetic resonance imaging images were evaluated at the ankle level from all participants. The PBTT was measured as the thickest point at the transverse image of the peroneus brevis tendon. The PBTCSA was measured as the cross-sectional ligament whole area of the peroneus brevis tendon that was most hypertrophied in the axial A-MR images. The average PBTT was 2.22 ± 0.29 mm in the normal group and 2.85 ± 0.36 mm in the PBT group. The average PBTCSA was 6.98 ± 1.54 mm^2 in the normal group and 13.11 ± 2.45 mm^2 in the PBT group. PBT patients had significantly greater PBTT ($P < .001$) and PBTCSA ($P < .001$) than the normal group did. A receiver operating characteristic curve analysis revealed that the most suitable cutoff value of the PBTT was 2.51 mm, with 81.8% sensitivity and 81.8% specificity, and an AUC for the score was 0.93. The most suitable cutoff value of the PBTCSA was 10.08 mm^2, with 90.9% sensitivity and 90.9% specificity, and AUC for the score was 0.98. Even though the PBTT and PBTCSA were both significantly associated with PBT, the PBTCSA was a more sensitive diagnostic parameter.

Abbreviations: A-MRI = Ankle-Magnetic resonance imaging, PBT = peroneus brevis tendinitis, PBTCSA = peroneus brevis tendon cross-sectional area, PBTT = peroneus brevis tendon thickness.

Keywords: diagnosis, peroneus brevis tendinitis, peroneus brevis tendon cross-sectional area, peroneus brevis tendon thickness

1. Introduction

Peroneal tendon disorder is a main cause of lateral ankle instability and pain.[1–3] The pathophysiology of lateral ankle disease usually involves a repetitive micro trauma, inversion injury from antecedent tendinopathy, or lateral ankle instability. Typical peroneal tendon pathology includes tenosynovitis, tendinopathy, peroneal retinacular injuries, full and partial thickness tendon tears, and tendon dislocations and subluxations. Systemic diseases such as rheumatoid arthritis, diabetes mellitus, collagen vascular disease, and renal failure are associated with peroneal tendon injury.[3–6] The peroneal tendon complex includes peroneal tendon sheaths, peroneus longus tendon, superior peroneal retinaculum, inferior peroneal retinaculum, and the peroneus brevis muscle and tendon.[2] The peroneus brevis muscle originates at two thirds of the distal lateral fibula and inserts onto the adjacent tuberosity on the lateral face of the proximal 5th metatarsal bone.[4,7] The peroneus brevis

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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tears and inflammations are frequently misdiagnosed because of the uncertain pain location associated with the lateral ankle anatomy. Physical examinations find that local swelling along the course of the peroneus brevis tendon sheath, subluxing tendons, and pain with eversion are diagnostic signs of peroneal pathologic disorder.[6,8,9] The cause of peroneus brevis tendinitis (PBT) is still incompletely understood. Possible causes include a subluxing peroneal tendons, a sharp posterior ridge of the fibula, instability of the peroneal retinaculum, overcrowding of the peroneal groove, lateral ankle instability, hypovascularity of the peroneus brevis tendon, contraction of the peroneus longus, and a peroneal groove of the fibula.[10–12] Conservative managements are almost always first-line treatment. However, more complicated cases, such as resection of the severely damaged tendon of the distal segments to the peroneus longus, need surgical therapy. Thus, to obtain early diagnosis, exact objective morphological parameters are necessary. Ankle-Magnetic resonance images (A-MRI) promote the assessment of the pathologic findings of the peroneus brevis tendon and other associated pathologic conditions in the ankle anatomy.[1,2,5] Many treating physicians also consider the A-MRI conditions when assessing morphologic abnormalities in the peroneus brevis tendon in order to decide on therapeutic options. Previous investigations evaluated the peroneus brevis tendon using a simple linear measurement at the approximate "middle" or "halfway" of the peroneus brevis tendon.[6] However, an asymmetric inflammatory thickening or partial tear of the peroneus brevis tendon can occur everywhere. Therefore, a measurement bias can occur frequently. As compared with the peroneus brevis tendon thickness (PBTT), the peroneus brevis tendon cross-sectional area (PBTCSA) may remain unaffected by this measurement bias, because the PBTCSA measures the cross-sectional area of the peroneus brevis tendon. Therefore, to evaluate the inflammatory hypertrophy of the whole peroneus brevis tendon, we devised the PBTCSA as a new objective morphological diagnostic parameter. We assumed that the PBTCSA is a key morphologic parameter in PBT diagnosis. Thus, we used A-MRI to compare the PBTT and PBTCSA between PBT patients and control groups.

2. Methods

2.1. Patients

The retrospective research material used to support the findings of this research were approved by Institutional Review Board. (IRB number: IS19RISI0049). We reviewed patients who visited the pain clinic with lateral ankle and foot pain from January 2015 to November 2018 and who had taken A-MRI.

The PBT inclusion group was as follows:

(1) pain at the lateral ankle;
(2) pain that worsens during activity and lessens during rest;
(3) pain when turning the foot in or out;
(4) swelling at the lateral ankle; and
(5) instability of the ankle when bearing weight.

Our exclusion criteria was follows;

(1) foot or ankle surgery;
(2) posterior tibialis tendon pathology;
(3) neuromuscular diseases
(4) plantar fasciitis

A total of 22 individuals who met our enrollment criteria were included after PBT diagnosis was confirmed by an experienced board-certified diagnostic radiologist.

There were 10 males and 12 females with an average age of 45.82 ± 14.69 years (range, 19–67 years) (Table 1). To compare the PBTT and PBTCSA between subjects with and without PBT, we enrolled control subjects. The normal group was subjects who wanted to take A-MRI for an exact diagnosis but had no proof of PBT. In the normal group, 22 subjects (10 males and 12 females) were enrolled with an average age of 39.77 ± 15.49 years (range, 16–63 years).

2.2. Imaging parameters

A-MRI was done using a 3T-MRI system (MAGNETOM Skyra® Siemens) and 3T Philips Ingenia scanners (Philips Healthcare, Eindhoven). We obtained transverse T1-weighted proton-density (PD), turbo-spin-echo (TSE) images with a slice thickness of 3.0 mm, intersection gap of 0.9 mm, time of repetition 869 milliseconds, time of echo 12 milliseconds, 150 × 150-cm field of view, 448 × 314 matrix, and > 3 echo-train length for all A-MRI examinations.

2.3. Image analysis

PBTT and PBTCSA measurements were analyzed by the experienced pain physician, who was blinded to the groups' ankle anatomy. We checked transverse T1-weighted A-MR images at the thickest point of the peroneus brevis tendon. We measured the PBTT and PBTCSA on A-MRI using a medical-imaging technology (INFINITT PACS system; Infinitt Healthcare, Incheon, Korea) (Fig. 1A and B). The PBTCSA was measured as the entire cross-sectional ligament area of the peroneus brevis tendon that was most hypertrophied in the transverse A-MR images.

2.4. Statistical analysis

Statistical comparisons of data are presented as standard deviation (SD) and mean. We compared the PBTT and PBTCSA between the PBT and the normal subjects by using *t*-tests. The diagnostic performance of the PBTT and PBTCSA was estimated by the receiver–operator characteristics curves, sensitivity, specificity, area under the curve (AUC), cutoff values, and 95% confidence intervals (CIs). A $P < .05$ were considered statistically significant. We used the statistical software package SPSS version 22.0 (IBM Corp., ISH version, Incheon, Korea) for the diagnosis value of the PBT.

Table 1

Comparison of the characteristics of the control and PBT groups.

Variable	Control groupn = 22	Pbt groupn = 22	Statistical significance
Gender (male/female)	10/12	10/12	NS
Ankle image (Rt/Lt)	11/11	10/12	NS
Age (yrs)	39.77 ± 15.49	45.82 ± 14.69	NS
PBTT (mm)	2.22 ± 0.29	2.85 ± 0.36	$P < .001$
PBTCSA (mm^2)	6.98 ± 1.54	13.11 ± 2.45	$P < .001$

Data represent the mean ± standard deviation (SD) or the numbers of patients.

NS = not statistically significant ($P > .05$), PBT = peroneus brevis tendinitis, PBTCSA = peroneus brevis tendon cross-sectional area, PBTT = peroneus brevis tendon thickness.

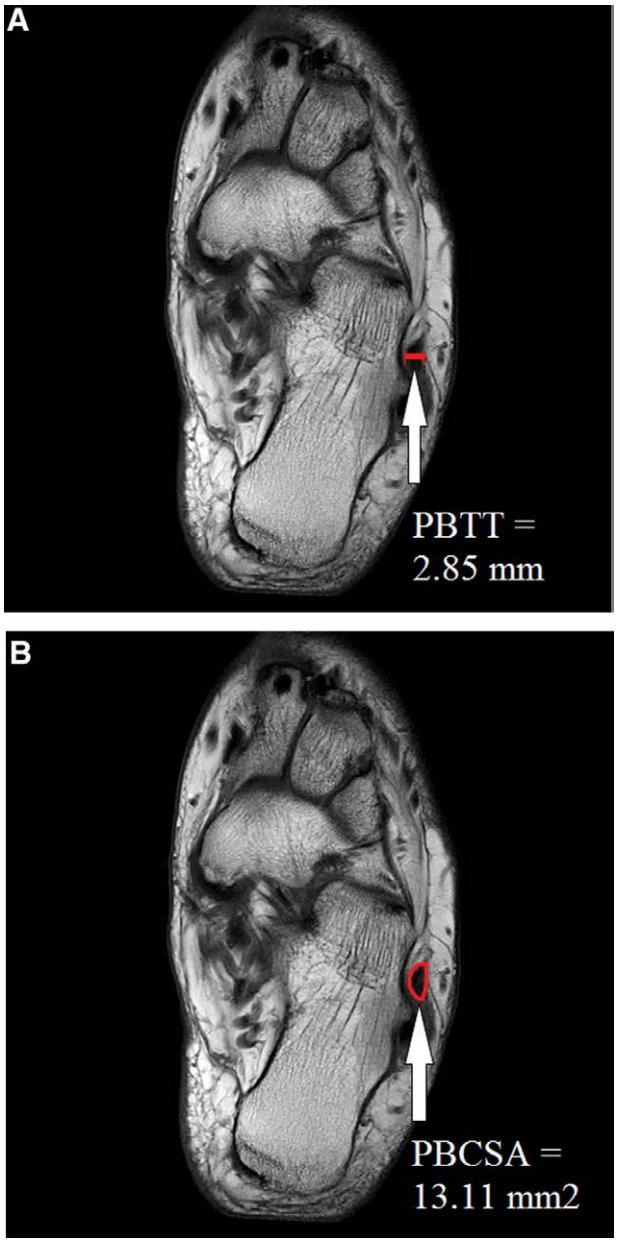

Figure 1. Measurement of both peroneus brevis tendon thickness (PBTT) (white arrow) (A) and peroneus brevis tendon cross-sectional area (PBTCSA) (white arrow) (B) in the peroneus brevis tendinitis carried out on A-MRI transverse T1-weighted images. A-MRI = Ankle-Magnetic resonance imaging, PBTCSA = peroneus brevis tendon cross-sectional area, PBTT = peroneus brevis tendon thickness.

3. Results

No significant differences between the 2 groups' mean values were found in the demographic data (Table 1). The average PBTT was 2.22 ± 0.29 mm in the normal group and 2.85 ± 0.36 mm in the PBT group. The average PBTCSA was 6.98 ± 1.54 mm^2 in the normal group and 13.11 ± 2.45 mm^2 in the PBT group. PBT subjects had significantly higher PBTT ($P < .01$) and PBTCSA ($P < .01$) than did the normal subjects (Table 1). A Receiver Operator Characteristics curve analysis concluded that the best cutoff point of the PBTT was 2.51 mm, with 81.8% sensitivity, 81.8% specificity, and an AUC of 0.93 (95% CI, 0.87-1.00) (Table 2, Fig. 2). The most suitable cutoff point of the PBTCSA was 10.08 mm^2, with 90.9% sensitivity, 90.9% specificity, and an AUC of 0.98 (95% CI, 0.96-1.00) (Table 3, Fig. 2.).

Table 2

Sensitivity and specificity of each cutoff point of the PBTT.

PBTT (mm)	Sensitivity (%)	Specificity (%)
1.68	100	4.5
2.35	95.5	63.6
2.44	90.9	72.7
2.51[a]	81.8	81.8
2.57	77.3	90.9
4.84	0	100

aThe best cutoff point on the receiver operating characteristic (ROC) curve.
PBTT = peroneus brevis tendon thickness.

4. Discussion

There are multiple types of pathologic disorders of the peroneal tendons, which include tenosynovitis, tendon tear, tendinopathy, and tendon dislocation or subluxation. Peroneal tendon diseases were once thought to be uncommon, but, with the advent of A-MRI, pathologic conditions of the peroneal tendons are being increasingly diagnosed as a main cause of lateral ankle instability and pain.[10,13,14] PBT is most commonly described in athletic populations involved in sporting activities, such as ballet, competitive walking, and running, which place repetitive mechanical stress on the ankle tendons. The pathologic condition has also been seen in elderly patients with diabetics, inflammatory arthritis, and past medical history of the calcaneus and lateral malleolus.[4,8,15] Previously described A-MRI findings in patients with PBT have increased signal intensity within the peroneus brevis tendon and included thickening of the tendon. However, Kijowski et al have reported that increased signal intensity within the peroneus brevis tendon was a nonspecific finding, and was also frequently observed in normal subjects.[16] Schmidt et al have analyzed the mean diameter of the peroneus brevis tendon inferior to the lateral malleoli as 2.5 mm via ultrasonography.[17] In this research, the mean PBTT was 2.22 ± 0.29 mm in the control group. The average PBTT was 2.85 ± 0.36 mm in the PBT group. The diameter measurements were obtained only at the midpoint between the insertion site.[6] However, the morphology of the peroneus brevis tendon injury can differ in terms of tendon discontinuity, a wavy or curved contour, contour elongation, irregularities, and different signal intensities within the peroneus brevis tendon. Moreover, Cabral et al have insisted that none of the measurement skills related to the peroneus brevis tendon are correlated with the tendons' sectional shape, perhaps because of the variations in its dimensions, which make it difficult to analyze its exact diameter.[1] Therefore, the measurement mistakes could occur at any time.

We assumed that the entire cross-sectional area of the peroneus brevis tendon may predict PBT, because the PBTCSA is not influenced by this measurement mistake, since the PBTCSA measures the entire cross-sectional area of the peroneus brevis tendon, in contrast to the PBTT. We eventually demonstrated that the PBTCSA is better than the PBTT as a diagnostic parameter of PBT. In the current research, we found that the PBTCSA had 90.9% sensitivity, 90.9% specificity, and an AUC of (95% CI) = 0.98 (0.96–1.00) to predict PTTD. In contrast, the PBTT had 81.8% sensitivity, 81.8% specificity, and an AUC of (95% CI) = 0.93 (0.87–1.00). These consequences suggest that the PBTCSA is a better diagnostic predictor of PBT than is the PBTT. We also analyzed T1-weighted transverse A-MR images, because the tendons can be clearly seen on A-MRI as hypointense anatomic structures on T1 images. The T1-weighted images also show good concrete anatomical details at the sites of pathology as in tendon injury.[2,16]

There are several methodological limitations that should be addressed in this research. First, several alternative imaging techniques for the peroneus brevis tendon, such as CT,

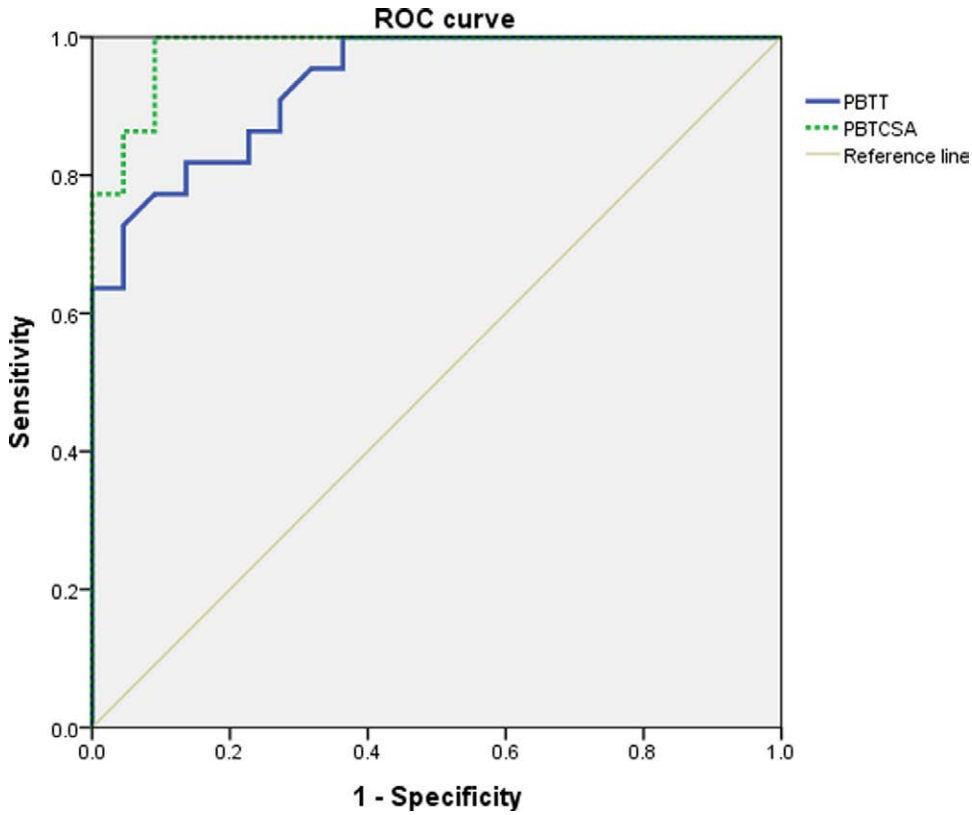

Figure 2. ROC curve of PBTT and PBTCSA for prediction of PBT. The best cutoff point of PBTT was 2.51 mm versus 10.08 mm^2 of PTTCSA, with sensitivity 81.8% versus 90.9%, specificity 81.8% versus 90.9% and AUC 0.93 versus 0.98, respectively. PBTT AUC (95% CI) = 0.93 (0.87–1.00). PBTCSA AUC (95% CI) = 0.98 (0.96–1.00). AUC = area under the curve, PBT = peroneus brevis tendinitis, PBTCSA = peroneus brevis tendon cross-sectional area, PBTT = peroneus brevis tendon thickness, ROC = Receiver operating characteristic.

Table 3

Sensitivity and specificity of each cutoff point of the PBTCSA.

PBTCSA (mm2)	Sensitivity (%)	Specificity (%)
4.89	100	4.5
5.95	100	22.7
6.44	100	40.8
10.08[a]	90.9	90.9
10.94	77.3	95.5
12.85	54.5	100

aThe best cutoff point on the receiver operating characteristic (ROC) curve.
PBTCSA = peroneus brevis tendon cross-sectional area.

radiography, US, and A-MRI should be used to evaluate PBT. Especially, the diagnostic US images can provide useful information for diagnosing and directing treatment.[18–29] However, we focused only on how to measure the PBTCSA and PBTT on A-MRI. Second, there might be measurement errors associated with evaluating the PBTCSA and PBTT on A-MRI. Even though we tried to analyze these morphologic images in the transverse image that showed the peroneus brevis tendon exactly, the transverse images could be inhomogeneous because of differences in the cutting level in the A-MRI as a result of technical problems and individual morphological variation. Third, the peroneal tendon complex includes the peroneus brevis tendon and muscle, peroneus longus tendon and muscle, peroneal tendon sheaths, inferior peroneal retinaculum, and superior peroneal retinaculum. However, we focused only on the thickened PBT, because our goal was to enable early diagnosis of PBT to prevent lateral ankle instability. In spite of these limitations, this is the 1st research to disclose that the PBTCSA is associated with PBT.

5. Conclusions

Although the PBTCSA and PBTT were both significantly associated with PBT, the PBTCSA was a more sensitive measurement parameter for PBT than was PBTT. We identified the best cutoff value of the PBTCSA as 10.08 mm^2, with 90.9 % sensitivity and 90.9 % specificity. When assessing patients with PBT, physicians should carefully evaluate the PBTCSA as a new objective parameter.

Author contributions

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