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Diagnostic value of the posterior talofibular ligament area for chronic lateral ankle instability

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Abstract

An injured posterior talofibular ligament (PTFL) is one of the reasons for chronic lateral ankle instability (CLAI). Previous researches have demonstrated that the PTFL thickness (PTFLT) is associated with chronic ligament injuries. However, ligament hypertrophy is different from ligament thickness. Thus, we created the PTFL cross-sectional area (PTFLCSA) as a diagnostic image parameter to assess the hypertrophy of the whole PTFL. We assumed that the PTFLCSA is a key morphological diagnostic parameter in CLAI. PTFL data were obtained from 15 subjects with CLAI and from 16 normal individuals. The T1-weighted axial ankle-MR (A-MR) images were acquired at the level of PTFL. We measured the PTFLT and PTFLCSA at the posterior aspect of the ankle using our imaging analysis program. The PTFLT was measured as the thickness between point of anterior and posterior fiber of PTFL. The PTFLCSA was calculated as the whole cross-sectional PTFL area. The average PTFLT was 3.43 ± 0.52 mm in the healthy group and 4.89 ± 0.80 mm in the CLAI group. The mean PTFLCSA was 41.06 ± 12.18 mm^2 in the healthy group and 80.41 ± 19.14 mm^2 in the CLAI group. CLAI patients had significantly greater PTFLT ($P < .001$) and PTFLCSA ($P < .001$) than the healthy group. A receiver operating characteristic curve analysis demonstrated that the optimal cutoff score of the PTFLT was 4.19 mm, with 93.3% sensitivity, 93.7% specificity, and an area under the curve of 0.97. The most suitable cutoff value of the PTFLCSA was 61.15 mm^2, with 93.3% sensitivity, 100% specificity, and area under the curve of 0.99. Even though the PTFLT and PTFLCSA were both significantly associated with CLAI, the PTFLCSA was a more exact morphological measurement parameter.

Abbreviations: A-MR = ankle-magnetic resonance, ATFL = anterior talofibular ligament, CFL = calcaneofibular ligament, CLAI = chronic lateral ankle instability, MRI = MR imaging, PTFL = posterior talofibular ligament, PTFLCSA = PTFL cross-sectional area, PTFLT = PTFL thickness, ROC = receiver operating characteristic.

Keywords: chronic lateral ankle instability, cross-sectional area, posterior talofibular ligament, thickness

1. Introduction

Lateral ankle ligamentous sprain is considered as one of the most common injuries affecting the lateral ligaments of the ankle. According to previous researches, 20 to 30% of all sports injuries are ankle injuries. Lateral ankle ligamentous sprain are frequently partially treated. The rate of repeated ankle sprain is >40%, and recurrent ankle injury can lead to chronic lateral ankle instability (CLAI) and ankle osteoarthritis.[1–4] The lateral ankle ligament is very important to maintain static and dynamic ankle stability and intact ligaments for movement and support functions of ankle and foot.[5,6] As we already know, frequent injuries of the ligaments such as calcaneofibular ligament (CFL), deltoid ligament and anterior talofibular ligament (ATFL), lead to CLAI.[5–8] However, there is no attentions about the relationship between CLAI and posterolateral ankle ligaments such as posterior talofibular ligament (PTFL). PTFL on the ankle-magnetic resonance (A-MR) image is visualized between the medial surface of the lateral malleolus and talus.[9–11] The original insertions of the posterior and anterior fibers of the PTFL are the medial aspect of the lateral malleolus of the fibula. The posterior fibers of the PTFL were attached into the lateral tubercle of the posterior process of the talus. The anterior fibers were attached into the surface of the lateral talus posterior to the lateral malleolar facet.[11] An injured PTFL has been thought to be one of an important finding of CLAI.[11,12] A-MR images facilitate the analysis of the pathologic disorders of the PTFL.[13] However, many treating doctors rarely consider the A-MR findings when assessing chronic morphologic changes in the PTFL in the CLAI patients.

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Moreover, previous researches only analyzed the PTFL using a single measurement at the approximate "halfway" of the PTFL. However, an asymmetrical thickening and partial tear of the PTFL can occur anywhere.[14] Therefore, measurement mistakes could occur in some cases. In contrast to the PTFL thickness (PTFLT) between anterior and posterior fiber, the cross-sectional area of PTFL does not worry about these measurement mistakes because the PTFL cross-sectional area (PTFLCSA) measures the whole PTFLCSA. Thus, to assess the hypertrophy of the PTFL, we created the PTFLCSA as an adjuvant new image diagnostic parameter. We assumed that the PTFLCSA is an important morphologic parameter in CLAI diagnosis. Thus, we used A-MR to compare the PTFLT and PTFLCSA between CLAI patients and healthy groups.

2. Materials and methods

2.1. Patients

This retrospective research has been examined by the Catholic Kwandong Univertsity Institutional Review Board. (IRB no: IS19RISI0049). We reviewed CLAI patients who diagnosed our orthopedic clinic with ankle discomfort from May 2016 to January 2019 and who had taken A-MR. The criteria for inclusion of CLAI were as follows: past history of recurrent ankle injuries; chronic lateral ankle discomfort and persistent pain on anterior drawer test; no feel confident exercise; had not responded to conservative treatment; and at least 1 year has elapsed since the first ligament injury, but ankle pain persists. Patients were excluded if they had any following issues: past ankle surgical history such as the ankle arthroscopy, modified Broström procedure, peroneal nerve disorder, and hindfoot varus.

There were 4 (26.6%) males and 11 (73.4%) females with a mean age of 38.60 ± 14.36 years (range, 16 to 59 years) (Table 1). To compare the PTFLT and PTFLCSA between the CLAI group and normal group, we also enrolled healthy individuals. In the normal group, 16 subjects (8 males and 8 females) were enrolled with a mean age of 38.13 ± 17.51 years (range, 16–65 years).

Table 1

Comparison of the characteristics of the control and CLAI groups.

Variable	Control group n = 16	CLAI group n = 15	Statistical significance
Gender (male/female)	8/8	4/11	NS
Ankle image (Rt/Lt)	10/6	8/7	NS
Age (yr)	38.13 ± 17.51	38.60 ± 14.36	NS
PTFLT (mm)	3.43 ± 0.52	4.89 ± 0.80	$P < .001$
PTFLCSA (mm^2)	41.06 ± 12.18	80.41 ± 19.14	$P < .001$

Data represent the mean ± standard deviation (SD) or the numbers of patients.
CLAI = chronic lateral ankle instability, NS = not statistically significant ($P > .05$), PTFLCSA = posterior talofibular ligament cross-sectional area, PTFLT = posterior talofibular ligament thickness.

2.2. Imaging parameters

A-MR scans were performed on a 3.0-T Siemens MAGNETOM Avanto (Siemens Healthcare, Munich, Germany) and 3T Ingina scanners (Philips, Eindhoven, Netherlands). The A-MR imaging (MRI) protocols included the following sequences: repetition time 603-ms/echo time 19-ms, high resolution axial T1-weighted images, a slice thickness of 3.0 mm, intersection gap of 0.9 mm, 484 × 471 matrix, 140 × 140 cm field of view, and >3.0 ETL.

2.3. Image analysis

PTFLT and PTFLCSA measurements were analyzed by the one specialist, who was blinded to the ankle classification. We acquired the T1 weighted axial MR cut at the thickest view of the PTFL. We measured the PTFLT and PTFLCSA on MR images using an image analysis software (INFINITT PACS system, Seoul, South Korea). (Fig. 1A and B). The PTFLT was measured as the thickness between point of anterior and posterior fiber of PTFL. The PTFLCSA was measured as the cross-sectional area of the PTFL that was extremely hypertrophied on T1-weighted MR images.

2.4. Statistical analysis

We compared the PTFLT and PTFLCSA between the CLAI and the normal healthy groups using unpaired *t* tests. Data are presented the mean standard deviations. A receiver operating characteristic (ROC) curve analysis was generated for diagnostic method. *P* values <.05 were considered statistically significantly different. We used options in the SPSS package (IBM/SPSS for Windows ver 22.0, Chicago, IL) for the presentation and area under the curve (AUC) calculation of the ROC curve.

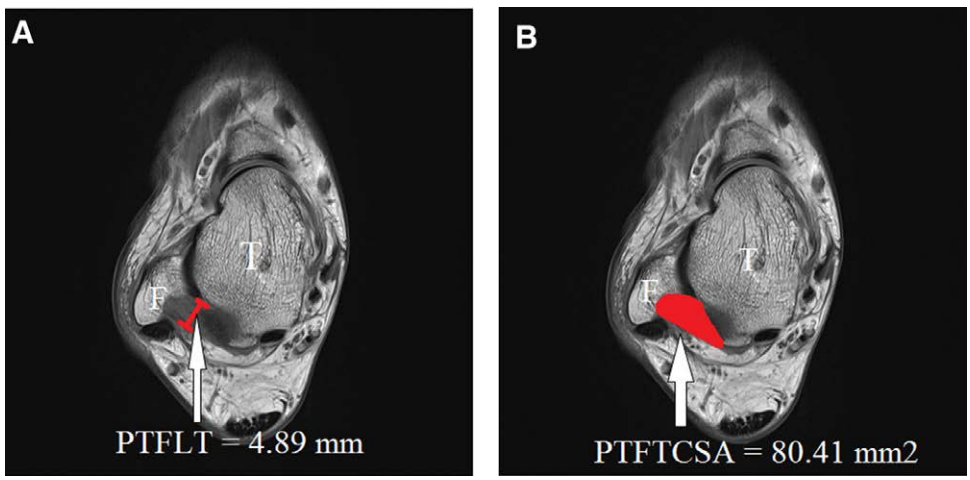

Figure 1. (A) Measurement of both posterior talofibular ligament thickness (PTFLT) (white arrow) and (B) posterior talofibular ligament cross-sectional area (PTFLCSA) (white arrow) in the chronic lateral ankle instability group was carried out on MR T1 weighted images. F = fibula, MR = magnetic resonance, T = tibia.

3. Results

Demographic datas such as age, ankle image, and gender that a similar arbitrary selection is being made between groups. The mean PTFLT was 3.43 ± 0.52 mm in the healthy group and 4.89 ± 0.80 mm in the CLAI group. The average PTFLCSA was 41.06 ± 12.18 mm^2 in the healthy group and 80.41 ± 19.14 mm2 in the CLAI group (Table 1). CLAI patients had significantly higher PTFLT ($P < .001$) and PTFLCSA ($P < .001$) than the control subjects (Table 1). A ROC curve analysis demonstrated that the most suitable cutoff score of the PTFLT was 4.19 mm, with 93.3% sensitivity, 93.7% specificity, and an AUC of 0.97 (95% CI, 0.92–1.00) (Table 2, Fig. 2). The most suitable cutoff point of the PTFLCSA was 61.15 mm^2, with 93.3% sensitivity, 100% specificity, and AUC of 0.99 (95% CI, 0.96–1.00) (Table 3, Fig. 2).

4. Discussion

Lateral ankle sprains are the most common disorders of sporting injuries. Even though most of these lateral ligament injuries treated well with non-operative treatment, the development of CLAI, characterized by the occurrence of repetitive ankle injuries and the persistence of symptoms, is common.[6,9,10,15] CLAI limits physical activity and leads to severe disability due to joint pains and osteoarthritis.[4,7,16–18] According to previous studies, approximately 25% of CLAI patients continue to suffer from ankle disabilities in spite of the successful management.[10] Multiple imaging systems, such as ultrasound, computed tomography, stress radiography and MRI, are available,[19] but the exact diagnosis of CLAI is still not easy due to the lack of a high sensitive objective morphological parameter. These results mean that the presence of untreated and undetected ligamentous complex. In this original research, we found the PTFL is one of the major cause of CLAI. We demonstrated that the optimal cutoff value of the PTFLCSA as 61.15 mm^2, with 93.3% sensitivity, 100% specificity. The best cutoff value of the PTFLT was 4.19 mm, with 93.3% sensitivity, 93.7% specificity.

The lateral collateral ligament complex is divided into ATFL, lateral talocalcaneal ligament, CFL, and PTFL. This complex is known to provide ankle stability against inversion of ankle joint. Chandnani et al have insisted that a 50% sensitivity and a 83% specificity for the assessment of the CFL and a 50% sensitivity and a 100% specificity for the assessment of the ATFL, when using MR arthrography.[9] Cha et al found the 60% sensitivity for ATFL injuries using MRI. However, there are few studies to evaluate relationship between PTFL and CLAI.[20] Zhu et al have demonstrated that the PTFL play an important role to maintain ankle stability. The serious injuries of PTFL would affect posterolateral ankle stabilities.[21] Liu et al reported that an increased ligament thickness reflects morphologic changes that have occurred secondary to chronic ankle ligament injuries.[22] Therefore, the PTFL was important to joint stability. The PTFL runs horizontally from a prominent tubercle on the posterior aspect of the talus immediately lateral to the groove for the flexor hallucis longus tendon to the malleolar fossa of the fibula lateral malleolus. It is the strongest lateral ligament, and plays an important role in ankle stability. PTFL also acts to limit posterior talar displacement and has under greatest strain in ankle dorsiflexion.[11] Our current research compared healthy group to those with CLAI. Our data indicated that healthy group have a PTFLT size of 3.43 mm and CLAI patients have PTFLT of 4.89 mm. However, we recognized some problems about measuring PTFLT. All previous researches evaluated the PTFLT using a single measurement of the PTFL between the anterior and posterior fibers. However, some studies demonstrated that the morphology of the ligament injury as a curved or wavy contour, ligament discontinuity, elongation, contour irregularities, and variable signal intensity in MRI.[23] Thus, measurement bias can occur. This study assumed that the cross-sectional area of the PTFL may predict CLAI exactly because the PTFLCSA is not influenced by this measurement bias since the PTFLCSA measures the whole PTFL area, in contrast to the PTFLT.

In the current research, we demonstrated that the PTFLCSA had 93.3% sensitivity, 100% specificity, and AUC of 0.99 (95% CI, 0.96–1.00) to predict CLAI. In contrast, the PTFLT had 93.3% sensitivity, 93.7% specificity, and AUC of 0.97 (95% CI of 0.92–1.00). These results concluded that the PTFLCSA is a valuable predictor of CLAI than the PTFLT.

Table 2

Sensitivity and specificity of each cutoff point of the PTFLT.

PTFLT (mm)	Sensitivity (%)	Specificity (%)
2.73	100	6.2
3.07	100	25.0
3.28	100	50.0
4.19*	93.3	93.7
4.52	60.0	100
5.42	20.0	100

PTFLT = posterior talofibular ligament thickness.
*The best cutoff point on the receiver operating characteristic (ROC) curve.

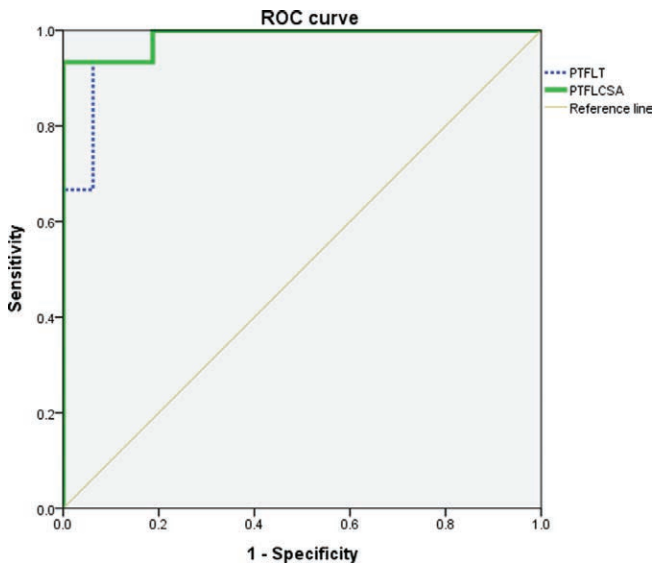

Figure 2. The best cut off point for PTFLCSA was 61.15 mm^2 versus 4.19 mm of PTFLT, with sensitivity 93.3% versus 93.3%, specificity 100% versus 93.7%. PTFLT AUC (95% CI) = 0.97 (0.92–1.00). PTFLCSA AUC (95% CI) = 0.99 (0.96–1.00). AUC = area under the curve, PTFLCSA = posterior talofibular ligament cross-sectional area, PTFLT = PTFL thickness.

Table 3

Sensitivity and specificity of each cutoff point of the PTFLCSA.

PTFLCSA (mm^2)	Sensitivity (%)	Specificity (%)
22.63	100	6.2
26.42	100	18.7
42.93	100	50.0
61.15*	93.3	100
67.74	73.3	100
73.99	53.3	100

PTFLCSA = posterior talofibular ligament cross-sectional area.
*The best cutoff point on the receiver operating characteristic (ROC) curve.

There are several important limitations of this research. First, small sample may be weakness of this research. Second, the ankle lateral ligament complex comprises the CFL ATFL, and the PTFL. In this study, we only focused on PTFL. Third, there are several different methods to assess CLAI, such as manual anterior drawer test, stress radiography, ultrasound examination or arthroscopy have been proved to be effective at discriminating CLAI.[24–33] However, we analyzed the PTFLCSA and PTFLT on MRI only.

Despite these limitations, this is the first research to document the association of PTFLCSA with CLAI. The PTFLCSA is a simple, reliable measurement tool with high sensitive value to evaluate CLAI.

5. Conclusion

The PTFLCSA was a more reliable measurement parameter for CLAI than PTFLT. We demonstrated that the best cutoff point of the PTFLCSA as 61.15 mm^2, with 93.3% sensitivity, 100% specificity. When assessing patients with CLAI, physicians should evaluate carefully the PTFLCSA rather than the PTFLT.

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