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Original Research

Morphology of the Incisura Fibularis at the Distal Tibiofibular Syndesmosis in the Japanese Population

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ABSTRACT

The morphology of the distal tibiofibular syndesmosis can determine the pathology and mechanism of syndesmotic injury. The present study assessed measurements obtained from computed tomography (CT) images of the normal distal tibiofibular syndesmosis in Japanese subjects. CT scans of 120 right feet with a normal distal tibiofibular syndesmosis obtained from January 2009 to December 2016 were retrospectively assessed at the level 10 mm proximal to the tibial plafond. The incisura fibularis was considered concave when its depth was ≥4 mm and shallow when its depth was <4 mm. The depth of the incisura fibularis, anterior tibiofibular distance (TFD), posterior TFD, and longitudinal/transverse length of the distal fibula were measured. The incisura fibularis was concave in 64.2% of the feet and shallow in 35.8%. The mean anterior TFD was 2.2 ± 0.8 mm (2.4 ± 0.8 mm in males; 2.1 ± 0.8 mm in females; 2.1 ± 0.8 mm for concave; 2.2 ± 0.9 mm for shallow). The mean posterior TFD was 5.9 ± 1.6 mm (6.7 ± 2.1 in males; 5.7 ± 1.3 mm in females; 5.5 ± 1.3 mm for concave; 6.5 ± 1.9 mm for shallow). The mean longitudinal/transverse length of the distal fibula at the level of the syndesmosis was 1.2 mm (1.3 mm in males; 1.2 mm in females; 1.1 mm for concave; 1.3 mm for shallow). The mean posterior TFD was significantly greater than the mean anterior TFD and was also significantly greater in males than in females. Significant differences were found in the body mass index, posterior TFD, and longitudinal/transverse length of the distal fibula according to whether the incisura fibularis was concave or shallow. The present study has provided measurements of the normal tibiofibular syndesmosis in the Japanese population. These data suggest that the morphology of the syndesmosis varies, especially with respect to whether the incisura fibularis is concave or shallow.

Distal tibiofibular syndesmotic injury occurs in ≤13% of all ankle fractures (1) and in 20% of patients requiring internal fixation of the ankle joint (2). Closed reduction of the distal tibiofibular joint results in malreduction in 16% to 52% of patients (3,4). The clinical outcomes of patients with malreduction are reported to be inferior to those of patients with an anatomic reduction (5). The need for anatomic reduction and stabilization of the injured syndesmosis is well established (6).

Small changes in the congruity of the ankle joint, including the distal tibiofibular syndesmosis, have marked effects on joint contact stresses (7,8). Widening of the ankle mortise by 1 mm decreases the contact area at the tibiotalar joint by 42% (9) and can lead to chronic instability, arthrosis, and further injury if not diagnosed and treated appropriately (10). Plain radiographs have limited sensitivity in detecting subtle displacement of the syndesmosis, and malalignment of the ankle joint is highly sensitive to positional changes (11,12).

Computed tomography (CT) has been more widely used in the evaluation of ankle injury in recent years. The advantages of CT-based evaluation of the distal tibiofibular syndesmosis are that, unlike plain radiographs, CT provides axial views of the syndesmosis and is substantially less dependent on ankle positioning at the time of imaging (13). Ankle injury can be difficult to diagnose using radiographic criteria; thus, it is important to be aware of the wide anatomic variability in the depth of the fibular incisura, width of the syndesmosis, and shape of the distal fibula at the distal tibiofibular syndesmosis. However, syndesmotic morphology has not been investigated in the Japanese population.

The present study assessed measurements taken from CT images of the normal distal tibiofibular syndesmosis in the Japanese population with the aim of identifying features that can help in the diagnosis of syndesmotic injury.

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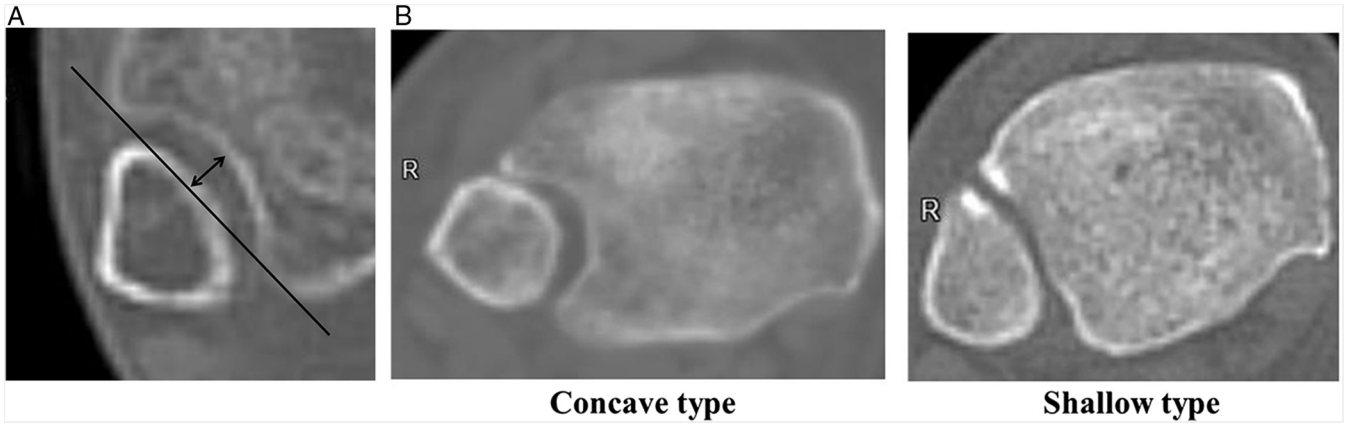

Fig. 1. (*A*) Distance from the deepest point at the fibular incisura to the nearest point on the tangent between the tip of the anterior tibial tubercle and the tip of the posterior tibial tubercle. (*B*) A fibular incisura with a depth of ≥4 mm indicates the syndesmosis has a deep (i.e., concave) shape and a depth of <4 mm indicates a shallow shape.

Patients and Methods

The present retrospective study was conducted with approval from the ethics board of Tokushima University Hospital. CT images taken of 120 right feet of 120 patients (31 males, 89 females) who had undergone total knee arthroplasty from January 2009 to December 2016 at our institution were subjected to analysis. Whole leg CT had been performed for evaluation of the knee alignment and surgical planning before total knee arthroplasty. Patients with a history of previous ankle trauma or surgery, those with a congenital or developmental deformity, and those with inflammatory arthritis were excluded.

The whole leg CT images were obtained in 1.0-mm-thick axial slices. The images were reviewed using the bone window setting (window 2200 HU; level 200 HU). CT scan data were imported into AquariusNET, version 1.6, software (TeraRecon Inc., San Mateo, CA) for analysis. The assessment was performed using axial CT images to assess the depth of the incisura fibularis, width of the distal tibiofibular syndesmosis, and shape of the distal fibula. The distal tibiofibular syndesmosis is generally measured at the level 10 mm proximal to the tibial plafond (14–19). Given that measurements of the distal tibiofibular syndesmosis taken from a position 1 cm above the ankle joint line are routinely accepted, we used measurements taken at this line. The morphology of the incisura fibularis was categorized as concave (a crescent-shaped syndesmosis) or shallow (a rectangular-shaped syndesmosis). The depth of the incisura fibularis was measured from its deepest point to the line between the tips of the anterior and posterior tubercles (Fig. 1*A*). The incisura fibularis was considered concave when its depth was ≥4 mm and shallow when its depth was <4 mm (Fig. 1*B*) (20).

The following parameters were measured across the syndesmosis:

1. Anterior tibiofibular distance (TFD), from point A at the anterior border of the fibula to point B at the nearest perpendicular point from point A on the anterior tibial tubercle (Fig. 2*A*)
2. Posterior TFD, from point C at the medial border of the fibula to point D at the nearest perpendicular point from point C on the lateral border of the posterior tibial tubercle (Fig. 2*A*)
3. Longitudinal length of the distal fibula (Fig. 2*B*)
4. Transverse length of the distal fibula (Fig. 2*B*)

The longitudinal/transverse length of the distal fibula was calculated by dividing the longitudinal length of the distal fibula (no. 3) by its transverse length (no. 4). An orthopedic surgeon who was not one of the study investigators and who was unaware of the purpose of the research recorded 3 sets of measurements for each parameter from which the average value was calculated.

Statistical Analysis

All data are reported as the mean ± standard deviation. Differences in the values obtained for each parameter were compared between groups using the unpaired *t* test, Mann-Whitney *U* test, or χ^2 test, as appropriate. All statistical analysis was performed using SPSS software, version 24.0 (IBM Corp., Armonk, NY). A p value $< .05$ was considered statistically significant.

Results

The mean patient age was 74.3 ± 7.8 years (73.3 ± 7.5 years for males; 74.5 ± 7.7 years for females). The mean body mass index (BMI) was 26.1 ± 3.8 kg/m^2 (25.5 ± 2.8 kg/m^2 for males; 26.4 ± 4.0 kg/m^2 for females). The morphology of the incisura fibularis was concave in

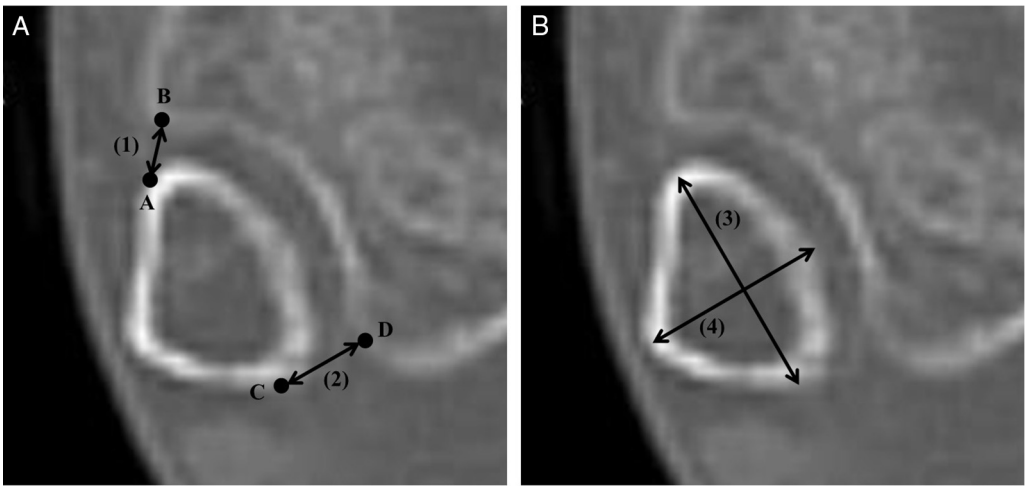

Fig. 2. (*A*) *(1)* indicates the anterior tibiofibular distance (TFD), which is the distance between point A (anterior border of the fibula) and point B (nearest perpendicular point from point A on anterior tibial tubercle); and *(2)* indicates the posterior tibiofibular distance, which is the distance between points C and D. Point C is the medial border of the fibula, and point D is the nearest point from point C on the lateral border of the posterior tibial tubercle. (*B*) *(3)* indicates the longitudinal length of the fibula on the distal tibiofibular syndesmosis, and *(4)* indicates the transverse length of the fibula on the distal tibiofibular syndesmosis.