

# Differences in Retromalleolar Fibular Groove Morphology According to Level of Axial Computed Tomography Scans

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**Background:** Studies have evaluated types of retromalleolar groove using axial magnetic resonance imaging at the level of 10 mm above the tip of the lateral malleolus. However, no evidence is available to support that this level is appropriate for evaluating retromalleolar groove morphology.

**Purpose:** To assess the influence of the level of axial computed tomography (CT) scans on the assessment of retromalleolar groove morphology.

**Study Design:** Cross-sectional study; Level of evidence, 3.

**Methods:** The study population included 122 patients (mean age,  $27.9 \pm 11.8$  years; 69 males, 53 female) who underwent CT scans to evaluate foot or ankle pathologies between 2020 and 2023. The shape of the retromalleolar groove (concave, flat, convex, or irregular) at 3 levels of axial CT scans (8, 10, and 12 mm above the tip of the lateral malleolus) was assessed independently by 2 orthopaedic surgeons. The length from the tip of the lateral malleolus to the proximal tip of the fossa of the lateral malleolus was also measured on coronal CT scans.

**Results:** The type of retromalleolar groove was significantly different according to the level of CT scans (8 vs 10 mm,  $P = .0001$ ; 10 vs 12 mm,  $P = .0001$ ; 8 vs 12 mm,  $P = .001$ ). The type of retromalleolar groove was the same at all 3 levels in 31.1% of patients (38/122). The length from the tip of the lateral malleolus to the proximal tip of the fossa of the lateral malleolus was <10 mm in 17.2% of patients (21/122).

**Conclusion:** The shape of the retromalleolar fibular groove was affected by the level at which the CT scan was obtained. Approximately 70% of the patients showed different types of retromalleolar grooves among the 3 CT scan levels.

**Keywords:** retromalleolar fibular groove; morphology; peroneal tendon disorders; computed tomography

Peroneal tendon pathologies commonly cause symptoms on the posterolateral side of the ankle joint, such as pain and a popping or snapping sensation. These pathologies include peroneal tendinopathy, peroneal tear or rupture, and peroneal tendon dislocation, and the preferred management of patients with peroneal tendon pathologies was proposed in the international consensus statement by the Ankle and Foot Associates of the European Society of Sports Traumatology, Knee Surgery, and Arthroscopy.<sup>16</sup> Many studies have reported risk factors associated with peroneal tendon pathologies.<sup>3,5,10,19</sup> Among these

risk factors, the relationship between the retromalleolar fibular groove morphology and the development of peroneal tendon disorders has been well discussed.<sup>1-3</sup> Whether the type of retromalleolar groove is a risk for peroneal tendon pathologies remains controversial. Ayanoglu et al<sup>2</sup> reported that a retromalleolar groove with a concave shape was a risk factor for peroneal tendon tears; however, Adachi et al<sup>1</sup> found no significant difference in the shape of the retromalleolar groove between patients with and without recurrent peroneal tendon dislocations.

Most previous studies reporting the characteristics of the retromalleolar groove evaluated the shape of the retromalleolar groove on axial magnetic resonance imaging (MRI) scans at a single scan level (10 mm above the tip of the lateral malleolus).<sup>1,2,4,13,14,18</sup> However, no evidence

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is available to support that this is the optimal level for evaluating retromalleolar groove morphology. Assessment of the shape of the retromalleolar groove using multiple slices rather than 1 slice may be better, considering the craniocaudal dimension of the retromalleolar groove. In addition, no method has been established for evaluating the shape of the retromalleolar groove. Computed tomography (CT) would be superior to MRI for the detailed assessment of the osseous morphology.<sup>3</sup> However, to our knowledge, only 1 study has investigated the shape of the retromalleolar groove using CT images.<sup>11</sup>

The purpose of the current study was to evaluate the influence of the level of axial CT scans on the assessment of retromalleolar groove morphology. It was hypothesized that the retromalleolar groove morphology would differ according to the level of the axial CT scan.

## METHODS

### Study Population

This single-center retrospective study received institutional review board approval. All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Declaration of Helsinki of 1975, as revised in 2013. Informed consent was obtained in the form of opt-out on our institution's website. The medical and imaging records of patients who underwent CT scans to evaluate foot or ankle pathologies in our hospital between January 1, 2020, and January 1, 2023, were reviewed. The foot and ankle CT data were identified through the medical center's picture archiving and communications system database. Excluded were patients with foot or ankle fractures, a history of surgical treatment of the fibula, ankle osteoarthritis, peroneal tendon disorders, chronic lateral ankle instability, open growth plate of the distal tibia and/or fibula, and CT scans obtained at an outside institution.

### Assessment of Retromalleolar Fibular Groove Morphology on CT Scans

In the study period, all CT images were obtained using a high-resolution CT apparatus (Canon Aquilion One). The scan of the lower extremity was performed in the neutral position with a slice distance of 2.0 mm and a field of view of 500 mm. The retromalleolar groove morphology was assessed on axial CT scans obtained at 3 levels:

8, 10, and 12 mm from the tip of the lateral malleolus. The axial CT slices were reconfigured using multiplanar reconstruction by a radiologist who was blinded to the patient's clinical information. The shape of the retromalleolar groove was classified into 4 types according to previous studies: concave, flat, irregular, or convex.<sup>4,13</sup> Two senior orthopaedic surgeons (T.Y. and Y.M.) conducted the evaluations independently. To evaluate the intrarater and interrater reliability of the assessments, each examiner independently evaluated the retromalleolar fibular groove morphology 2 times with a 4-week interval. A third senior orthopaedic surgeon (T.T.) resolved discrepancies between the 2 examiners.

### Length From the Tip of the Lateral Malleolus to the Proximal Tip of the Lateral Malleolar Fossa

In each patient, the distance from the tip of the lateral malleolus to the proximal tip of the lateral malleolar fossa was measured by 2 senior orthopaedic surgeons (T.Y. and Y.M.) to evaluate whether the level 10 mm above the tip of the lateral malleolus was above or below the proximal tip of the lateral malleolar fossa. The measurement was conducted with a standard digital caliper (X viewer; Yokogawa) on a coronal CT image (Figure 1). A coronal CT slice that showed the maximal distance between the tip of the lateral malleolus and the proximal tip of the lateral malleolar fossa was selected by the examiner. The mean value was used for the subsequent analysis.

### Statistical Analysis

All statistical analyses were performed using SAS software (JMP Pro, Version 15.2.0; SAS Institute). Descriptive statistics were reported as frequency and percentage or mean  $\pm$  standard deviation. The chi-square test was conducted for categorical variables, with the threshold of significance set at  $P > .05$ . The Cohen kappa coefficient ( $\kappa$ ) was calculated to assess the intrarater and interrater reliability of the CT measurements. The  $\kappa$  coefficient was presented with 95% CI and was graded according to the Landis classification (slight, 0.0-0.20; fair, 0.21-0.40; moderate, 0.41-0.60; substantial, 0.61-0.80; or almost perfect, 0.81-1.00).<sup>7</sup> The correlation of the patient's height to the distance from the tip of the lateral malleolus to the proximal tip of the fossa of the lateral malleolus was evaluated using the Spearman rank correlation coefficient, with the strength of the correlation defined as strong, 0.70 to 1.0; moderate, 0.40 to 0.69; or weak, 0.20 to 0.39.<sup>6</sup>

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Ethical approval for this study was obtained from Miyazaki University (ref No. O-1339).



**Figure 1.** Measurement of the length from the tip of the lateral malleolus to the proximal tip of the fossa of the lateral malleolus on a coronal computed tomography slice of the right ankle. First, a line perpendicular to the bone axis of the fibula is drawn (line 1). Second, a tangential line parallel to line 1 is drawn at the proximal tip of the fossa of the lateral malleolus (line 2). The distance between lines 1 and 2 is the length (arrow).

**RESULTS**

A total of 122 patients (122 ankles; 69 male and 53 female; 71 right ankles and 51 left ankles) were included in this study after exclusion of 20 patients for the following reasons: ankle fracture (n = 15), history of surgical treatment of the fibula (n = 3), and history of peroneal tendon disorders (n = 2). The pathologies of the included patients were osteochondral lesion of the talus (n = 37), posterior ankle impingement (n = 28), Achilles tendinopathy (n = 19), anterior ankle impingement (n = 18), ankle synovitis (n = 14), and osteomyelitis (n = 6). The mean age of the participants was 27.9 ± 11.8 years. The mean heights of the male and female participants were 171.3 ± 6.6 cm and 155.2 ± 14.7 cm, respectively.

**Retromalleolar Fibular Groove Morphology at Each CT Scan Level**

The type of retromalleolar groove for each CT scan level is shown in Table 1. A significant difference was observed in the shape of the retromalleolar groove according to the scan level (8 vs 10 mm, *P* = .0001; 10 vs 12 mm,

**TABLE 1**  
Retromalleolar Fibular Groove Morphology at Each CT Scan Level<sup>a</sup>

Shape	Distance From the Tip of the Lateral Malleolus		
	8 mm	10 mm	12 mm
Concave	32 (26.2)	43 (35.2)	32 (26.2)
Convex	58 (47.5)	47 (38.5)	41 (33.6)
Flat	30 (24.6)	30 (24.6)	39 (32)
Irregular	2 (1.6)	2 (1.6)	10 (8.2)

<sup>a</sup>Data are reported as n (%).

**TABLE 2**  
Intrarater and Interrater Reliability of the Retromalleolar Groove Morphology

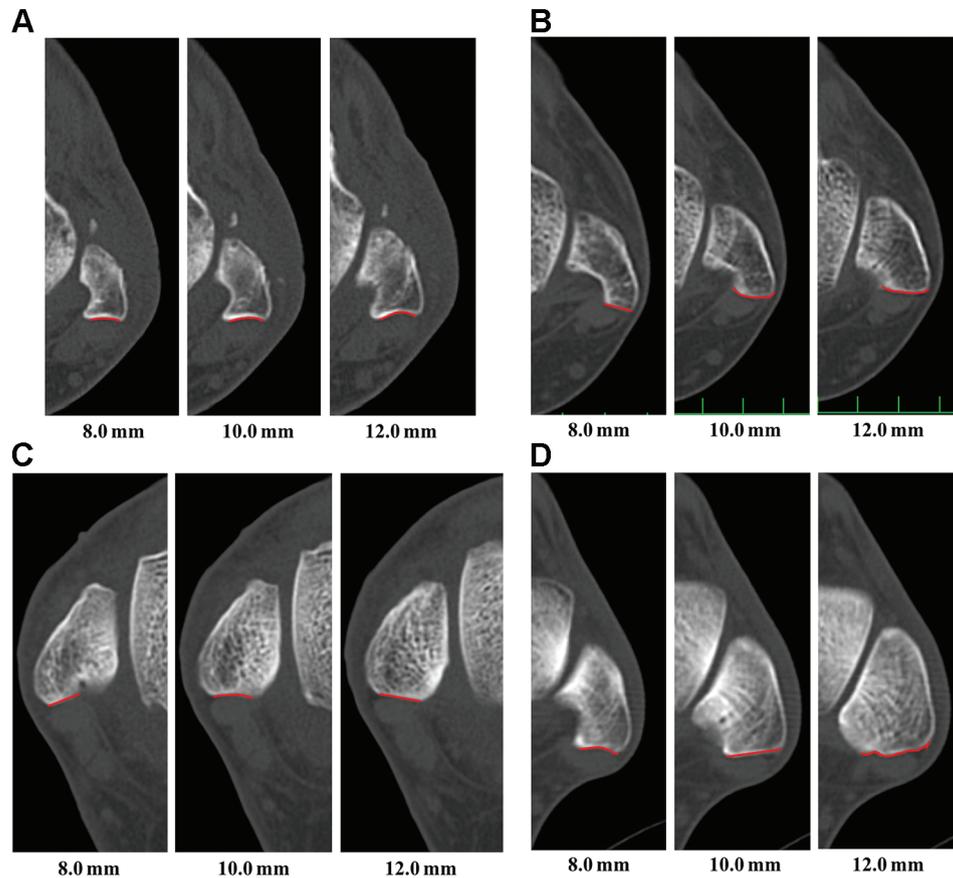
	$\kappa$ (95% CI)	<i>P</i>
<b>Intrarater reliability</b>		
Examiner 1		
8 mm	0.77 (0.62-0.93)	<.0001
10 mm	0.81 (0.67-0.95)	<.0001
12 mm	0.83 (0.70-0.96)	<.0001
Examiner 2		
8 mm	0.90 (0.80-1.00)	<.0001
10 mm	0.82 (0.67-0.96)	<.0001
12 mm	0.83 (0.69-0.97)	<.0001
<b>Interrater reliability</b>		
First round		
8 mm	0.68 (0.51-0.84)	<.0001
10 mm	0.72 (0.54-0.89)	<.0001
12 mm	0.74 (0.59-0.90)	<.0001
Second round		
8 mm	0.65 (0.47-0.82)	<.0001
10 mm	0.72 (0.55-0.89)	<.0001
12 mm	0.74 (0.58-0.90)	<.0001

*P* = .0001; 8 vs 12.0 mm, *P* = .001). The shape was the same at all 3 levels in 31.1% of the patients (38/122), and it was the same at 2 of the 3 scan levels in 59.8% of the patients (73/122). The shape was different at all 3 scan levels in 9.0% of the patients (11/122). Representative examples are shown in Figure 2.

When the type of retromalleolar groove at the 8-mm level was compared with that at the 10-mm level, 61.5% of patients (75/122) showed the same type. When the type of retromalleolar groove at the 10-mm level was compared with that at the 12-mm level, 54.1% of patients (66/122) showed the same type. When the type of retromalleolar groove at the 8 mm-level was compared with that at the 12-mm level, 42.6% of patients (52/122) showed the same type.

**Measurement Reliability**

The intrarater and interrater reliabilities of the measurements at each CT scan level are shown in Table 2. Regarding intrarater reliability for examiner 1, substantial



**Figure 2.** The shape of the retromalleolar groove at the 3 levels of computed tomography (CT) scans (8, 10, and 12 mm from the tip of the lateral malleolus) in 4 representative patients. (A) Patient 1 (left foot of a 32-year-old man). The shape of the retromalleolar groove was concave in all 3 CT slices. (B) Patient 2 (left foot of a 19-year-old woman). The shape of the retromalleolar groove was flat at the 8-mm level and convex at the 10-mm and 12-mm levels. (C) Patient 3 (right foot of an 18-year-old woman). The shape of the retromalleolar groove was flat at the 8-mm and 12-mm levels and concave at the 10-mm level. (D) Patient 4 (left foot of a 39-year-old man). The shape of the retromalleolar groove at the 8-mm, 10-mm, and 12-mm levels was concave, flat, and irregular, respectively.

agreement was detected at the 8-mm level from the tip of the lateral malleolus ( $\kappa = 0.77$ ), and almost perfect agreement was detected at the 10-mm ( $\kappa = 0.81$ ) and 12-mm levels ( $\kappa = 0.83$ ). For examiner 2, almost perfect agreement was detected at all 3 levels. The interrater reliability of the CT findings indicated substantial agreement at each scan level.

#### Length From the Tip of the Lateral Malleolus to the Proximal Tip of the Lateral Malleolar Fossa

The mean length from the tip of the lateral malleolus to the proximal tip of the lateral malleolar fossa was  $11.9 \pm 1.7$  mm (95% CI, 11.6-12.2 mm; range, 8.1-16.0 mm). In the study population, 21 patients (17.2%) had a length of <10 mm. A moderate correlation was identified between patient height and the length from the tip of the lateral malleolus to the proximal tip of the lateral malleolar fossa ( $r = 0.59$ ;  $P < .0001$ ).

#### DISCUSSION

The most important finding of the present study was that the shape of the retromalleolar fibular groove was affected by the level of the CT scan. The same type of retromalleolar groove at all 3 levels on CT scans obtained at 8, 10, and 12 mm from the tip of the lateral malleolus was found in only 31.1% (38/122) of the patients.

Several anatomic factors have been reported to predispose patients to peroneal tendon pathologies.<sup>2,3,5,9,10,19</sup> In particular, previous studies have investigated the influence of the shape of the retromalleolar groove on the incidence of peroneal tendon pathologies.<sup>1,2,9</sup> Additionally, retromalleolar groove deepening has been reported as an effective surgical procedure for patients who experience recurrent peroneal tendon dislocation.<sup>3,8,12,15,17</sup> Therefore, the correct assessment of the retromalleolar groove morphology is of great importance to foot and ankle surgeons. However, at present, the optimal method for evaluating the retromalleolar groove morphology has not been

established. Historically, the majority of authors evaluated the shape of the retromalleolar groove using 1 slice of an MRI scan (at the level of 10 mm above the tip of the lateral malleolus) according to the studies by Rosenberg et al.<sup>13</sup> and Wang et al.<sup>18</sup> Fundamentally, the slice thickness of the MRI scans differed depending on the study: 3.0 to 4.0 mm by Saupé et al.,<sup>14</sup> 2.5 to 3.0 mm by Matcuk et al.,<sup>9</sup> and 4.0 mm by Ayanoglu et al.<sup>2</sup> Thus, the axial MRI scans evaluated in these previous studies were not accurately obtained at the level of 10 mm above the tip of the retromalleolar groove. The present study showed that the shape of the retromalleolar groove differed when the MRI scan level changed. Therefore, the findings of the present study suggest that evaluating the shape of the retromalleolar groove using a single axial slice may not be appropriate.

In the present study, the length from the tip of the lateral malleolus to the proximal tip of the lateral malleolar fossa was <10 mm in 17.2% of the patients. A moderate correlation ( $r = 0.59$ ) was identified between the patient's height and the length from the tip of the lateral malleolus to the proximal tip of the lateral malleolar fossa. Namely, if the level of 10 mm above the tip of the lateral malleolus was applied to the study population, the level would be above the proximal tip of the lateral malleolar fossa in 82.8% of the patients and would be below that in 17.2%, indicating that the evaluated level of the axial slice would be affected by the bone morphology of the patient's lateral malleolus. Considering that the patient's height would affect the distance from the tip of the lateral malleolus to the proximal tip of the lateral malleolar fossa, the tibial plafond or a fixed level from the tibial plafond or the proximal tip of the lateral malleolar fossa may be a better slice for evaluating the retromalleolar groove morphology than the level of 10 mm above the tip of the lateral malleolus. The study findings again suggest that the type of retromalleolar groove should be assessed using multiple slices.

In this study, the type of retromalleolar groove was the same at all 3 levels in only 31.1% of the patients (38/122), and 91% of patients (111/122) showed the same type in 2 of the 3 slices. This finding provides further support that multiple slices will more accurately indicate the shape of the retromalleolar groove. Matcuk et al.<sup>9</sup> assessed the retromalleolar groove at 2 levels (at the ankle joint and 10 mm above the tip of the lateral malleolus). Although those authors did not statistically evaluate the difference in the proportion of types between the 2 levels, the interrater reliability at the level of the ankle joint ( $\kappa = 0.56$ ) was superior when compared with 10 mm above the tip of the lateral malleolus ( $\kappa = 0.34$ ). Nishimura et al.<sup>11</sup> evaluated the type of retromalleolar groove using CT scans obtained at 2 levels: the tibial plafond (TP level) and the center between the ankle joint and fibular tip (CS level). The authors reported 25 convex, 35 flat, and 0 concave retromalleolar grooves at the TP level and 19 convex, 34 flat, and 7 concave retromalleolar grooves at the CS level. However, their study did not describe the thickness of the CT scans and additionally did not analyze the intra- and inter-rater reliability of the assessment of the retromalleolar groove.<sup>11</sup> The present study investigated types of the retromalleolar groove at 3 levels and could not conclude how

many slices are appropriate or which slice level should be selected to evaluate the shape of the retromalleolar groove. This study also could not correlate groove shapes at different levels with peroneal tendon pathologies. Future studies will be needed to clarify these issues and find a reliable and standardized method for evaluating the shape of the retromalleolar groove.

### Limitations

There are several limitations to the present study. First, this study evaluated the types of retromalleolar groove using 3 CT scan levels. Therefore, the influence of other scan levels on the shape of the retromalleolar groove was not assessed. Second, this study evaluated CT findings from symptomatic patients, and we excluded patients with peroneal tendon disorders. Third, most previous studies investigated the shape of the retromalleolar groove using MRI scans. Therefore, the study findings may not be generalizable to the assessment of the retromalleolar groove on MRI scans. However, CT is generally superior to MRI for evaluating osseous morphologies. Fourth, the present study evaluated only Japanese patients. Japanese people are generally shorter on average than other populations, which may affect the study findings. Despite these limitations, the study findings will help orthopaedic surgeons better understand the shape of the retromalleolar groove, which will contribute to the establishment of an optimal method for evaluating the retromalleolar groove morphology.

### CONCLUSION

This study evaluated the retromalleolar fibular groove morphologies on axial CT scans at 3 levels: 8, 10, and 12 mm from the tip of the lateral malleolus. The retromalleolar fibular groove morphology was affected by the level of the axial CT scans. In this study, approximately 70% of the patients showed different types of retromalleolar grooves among the 3 CT scan levels.

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