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ANATOMIC VARIATIONS

Morphological characteristics of the lateral talocalcaneal ligament: a large-scale anatomical study

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Abstract

Purpose The purpose of this study is to clarify the morphological characteristics of the lateral talocalcaneal ligament (LTCL).

Methods This study examined 100 legs from 54 Japanese cadavers. The LTCL was classified into three types: Type I, the LTCL branches from the calcaneofibular ligament (CFL); Type II, the LTCL is independent of the CFL and runs parallel to the calcaneus; and Type III, the LTCL is absent. The morphological features measured were fiber bundle length, fiber bundle width, and fiber bundle thickness.

Results The LTCL was classified as Type I in 18 feet (18%), Type II in 24 feet (24%), and Type III in 58 feet (58%). All LTCLs were associated with the anterior talofibular ligament at the talus. There was no significant difference in morphological characteristics by Type for each ligament.

Conclusions The LTCL was similar to the CFL in terms of fiber bundle width and fiber bundle thickness.

Keywords Calcaneofibular · Ligament · Subtalar joint · Gross anatomy

Introduction

Of patients with chronic ankle instability, 42% [6] present with mechanical instability of the talocrural joint, and 58% have mechanical instability of the subtalar joint [3], each of them at high percentages. Although a previous study examined the association between CAI and mechanical instability of the subtalar joint, the number of reports is extremely low compared to reports concerning the talocrural joint [3]. This may be because the subtalar joint has intricate anatomical features, as well as complex three-dimensional mobility, making it a challenge to conduct quantitative evaluations.

Ligaments that are associated with the stability of the subtalar joint include the calcaneofibular ligament (CFL), the lateral talocalcaneal ligament (LTCL), the interosseous talocalcaneal ligament (ITCL), and the cervical ligament (CL). Many studies have reported the relationship between the CFL and the subtalar joint. On the other hand, there are only a few studies that have reported how the subtalar joint is associated with the LTCL, ITCL, or CL, indicating the absence of adequate investigations [4, 8]. In particular, although the involvement of the LTCL in the stability of the subtalar joint has been reported [4], it has also been shown that it restricts excessive supination of the subtalar joint [2], and that it limits abduction and adduction [8], indicating divergent views on its role in regulating the direction of movement. Thus, there is no current consensus on how the LTCL controls and restricts the mobility of the subtalar joint. This may be because there have been very few anatomical reports on the LTCL.

An anatomical study of the LTCL by Trouilloud et al. [7] reported that the LTCL branched from the CFL in 35%, the LTCL was independent from the CFL in 23%, and the

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LTCL was absent in 42% of the 20 legs investigated. There are also some differences, as Wiersma et al. [9] reported that the LTCL bridging between the CFL and ATFL was seen in 55%, the LTCL not bridging between the CFL and ATFL was seen in 11%,, and the LTCL was absent in 34% of the 44 legs. Moreover, Burks et al. [1] examined 39 legs and reported that the fiber bundle length and width of the LTCL were 26.5 mm and 4.4 mm, respectively. However, both reports included only a small number of samples.

The aim of this study, therefore, is to elucidate the morphological characteristics of the LTCL in a large sample size.

Materials and methods

Cadavers

This investigation examined 100 legs from 54 Japanese cadavers (mean age at death, 79 ± 13 years; 56 sides from men, 44 from women; 50 right sides, 50 left sides) that had been switched to alcohol after placement in 10% formalin. None showed signs of previous major surgery around the foot or ankle or any relevant deformities, and there was no obvious degeneration in all specimens. This study was approved by the Ethics Committee at our institution.

Methods

The dissection procedure for the LTCL is described below. First, isolated specimens of the leg were created by transection 10 cm above the ankle. Skin, subcutaneous tissue, muscle/tendon, and leg fascia were subsequently removed, and the LTCL was carefully exposed. Based on a previous study [7], the LTCL was classified as follows: type I, the LTCL branches from the CFL; type II, the LTCL is independent of the CFL and runs parallel to the calcaneus; and type III, the LTCL is absent. Based on a previous study [5], to assess the morphological characteristics of the LTCL, the anterior talofibular ligament (ATFL), and the CFL, the length, width, and thickness of the fiber bundles were measured. As for the ATFL, the total number of fiber bundles was determined. Measurements were made at the center of all ligaments using digital calipers (Shinwa Rules, Niigata, Japan). All measurements were performed by the same examiner.

Statistical analysis

The chi-squared test was used to compare differences by sex and laterality among the types. Comparisons of fiber bundle length, fiber bundle width, and fiber bundle thickness among the types for each ligament were made with the unpaired *t* test, one-way analysis of variance (ANOVA), and Bonferroni's method. Comparisons of fiber bundle length, fiber bundle width, and fiber bundle thickness for each ligament were made with one-way repeated-measures ANOVA and Bonferroni's method. The level of significance was 5%.

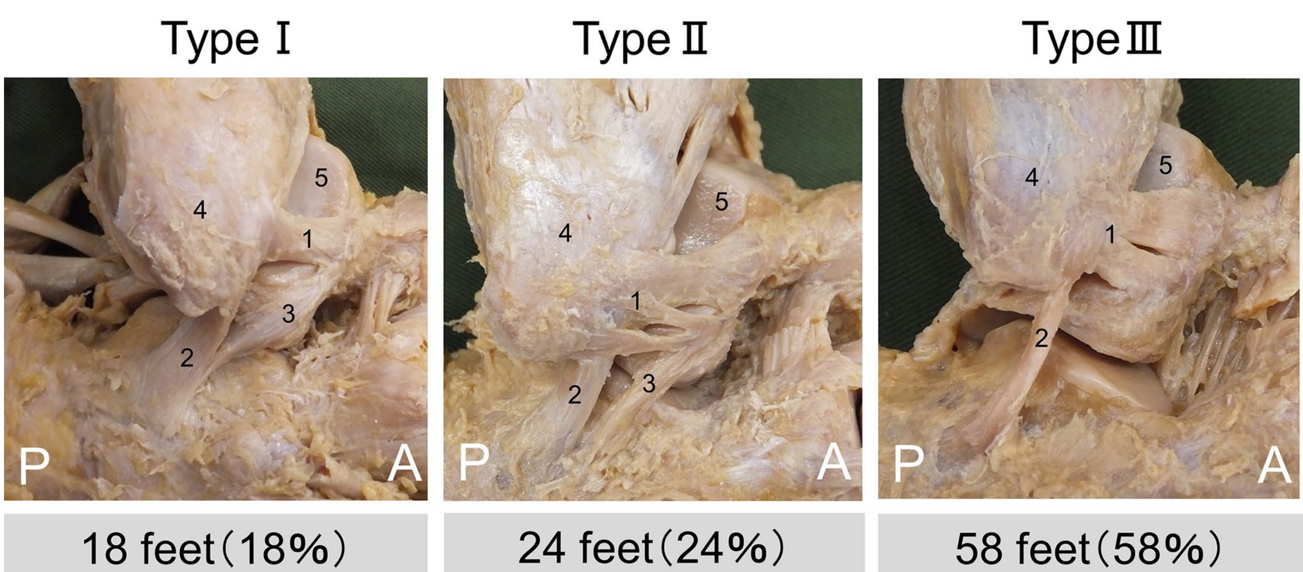

Fig. 1 Classification of the lateral talocalcaneal ligament. Type I: the LTCL combines with the CFL at the calcaneus. Type II: the LTCL runs parallel to the CFL at the calcaneus. Type III: the lateral talocalcaneal ligament is lacking. (1) Anterior talofibular ligament; (2) calcaneofibular ligament; (3) lateral talocalcaneal ligament; (4) fibula; (5) talus; *A* anterior, *P* posterior

Results

Classification of the lateral talocalcaneal ligament (Fig. 1)

Type I was seen in 18 feet (18%), type II in 24 feet (24%), and type III in 58 feet (58%). In addition, all LTCLs were connected to the ATFL at the origin at the talus.

In the comparison between men and women, the types in men were Type I in 8 legs (14.3%), Type II in 16 legs (28.6%), and Type III in 32 legs (57.1%), and the types in women were Type I in 10 legs (22.7%), Type II in 8 legs (18.2%), and Type III in 26 legs (59.1%). No significant differences were seen between men and women.

In determining differences between left and right legs, both legs of 46 cadavers (52 legs from 26 male cadavers, 40 legs from 20 female cadavers) could be measured. In comparisons between left and right legs, the right legs were Type I in 9 legs (19.6%), Type II in 12 legs (26.1%), and Type III in 25 legs (54.3%). The left legs were Type I in 9 legs (19.6%), Type II in 9 legs (19.6%), and Type III in 28 legs (60.8%). No significant differences were seen between the right and left legs.

Morphological characteristics of the lateral talocalcaneal ligament (Table 1)

No significant differences between types were seen in measurements of the LTCL. There was no significant difference in morphological characteristics among types for each ligament. The LTCL was similar to the CFL in terms of fiber bundle width and fiber bundle thickness.

Discussion

This study elucidated the morphological characteristics of the LTCL in Japanese cadavers. To the best of our knowledge, there have been no anatomical studies of the LTCL that examined a large sample size as in the present study.

In the present study, the LTCL was seen in 42% (Types I and II) of specimens. Trouilloud et al. [7] reported the percentages of Types I, II, and III to be 35%, 23%, and 42%, respectively. Wiersma et al. [9] reported the percentages of Types I, II, and III to be 55%, 11%, and 35%, respectively. The percentage of Type II, where the LTCL runs parallel to the CFL at the calcaneus, was similar to the study of Trouilloud et al. [[7]], although the percentages of the others were markedly different from previous findings.

Regarding the morphological characteristics of the LTCL, Burks et al. [1] reported the fiber bundle length and width of the LTCL to be 26.5 mm and 4.4 mm,

Table 1 Measurements of the lateral talocalcaneal ligament

	Type I			Type II			Type III			Mean		
	ATFL	CFL	LTCL	ATFL	CFL	LTCL	ATFL	CFL	LTCL	ATFL	CFL	LTCL
Length (mm)	21.7 ± 2.8	31.2 ± 4.3	24.6 ± 3.7	20.3 ± 2.7	31.6 ± 4.9	26.1 ± 3.9	21.1 ± 3.3	30.8 ± 4.3		21.0 ± 3.1	30.8 ± 4.3^{a,c}	25.4 ± 3.8^{a,b}
Width (mm)	7.1 ± 2.4	4.9 ± 1.2	4.1 ± 1.2	6.3 ± 2.5	4.4 ± 0.8	3.8 ± 1.9	6.8 ± 2.7	4.7 ± 1.3		6.8 ± 2.7	4.6 ± 1.2^{a}	4.0 ± 1.6^{a}
Depth (mm)	1.4 ± 0.5	1.8 ± 0.5	1.5 ± 1.3	1.5 ± 0.5	1.8 ± 0.4	1.6 ± 1.8	1.5 ± 0.6	1.9 ± 0.6		1.5 ± 0.6	1.8 ± 0.5^{a}	1.5 ± 1.6

Values are means ± SD

[a] $p < 0.01$, vs. ATFL

[b] $p < 0.01$, vs. CFL

[c] $p < 0.01$, vs. LTCL

respectively, similar to the present results. Moreover, the morphological characteristics of fiber bundle length and width of the LTCL were similar to those of the CFL.

All LTCLs were connected to the ATFL at the origin (talus). We hypothesized that the LTCL plays an auxiliary role to the ATFL and CFL based on their positional relationship, and that Types I and II with the LTCL have smaller fiber bundle width and thickness than Type III without the LTCL. However, there were no significant differences in the morphological characteristics of each ligament among the different types.

One limitation of this study is that the morphological characteristics of the LTCL alone were investigated using fixed cadavers, and biomechanical examinations were not conducted. In the future, it may be possible to elucidate the functional role of the LTCL through an in vivo classification and biomechanical investigation of the LTCL.

The results from this study will provide useful basic data related to instability of the subtalar joint. In the future, in vivo studies based on the present study data will be necessary.

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Author contributions ME, IK, and TK contributed to study design and data collection and drafted the manuscript; TT, WI, EN, RH, and TI contributed to data analysis and made critical revisions to the manuscript; MI, FK, AK, and HI made critical revisions to the manuscript; GO supervised the study, contributed to analysis and interpretation of data, and made critical revisions to the manuscript. All authors read and approved the final manuscript prior to submission.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The methods were carried out in accordance with the 1964 Declaration of Helsinki and the cadavers were legally donated for the research by the Nippon Dental University of Life Dentistry at Niigata in Japan.

Informed consent Informed consent was obtained from the families of all subjects.

Availability of data and material The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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