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Influence of Anterior Talofibular Ligament Injury and Ankle Anterior Displacement on Symptoms in Individuals With Chronic Ankle Instability

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Context: Repeated ankle sprains can lead to injuries, including those of the anterior talofibular ligament (ATFL); however, the extent to which these ligament injuries are associated with symptoms of chronic ankle instability (CAI) remains unclear.

Objective: To examine the influence of ATFL injury and ankle anterior displacement on symptoms of CAI.

Design: Case-control study.

Setting: University laboratory.

Patients or Other Participants: A total of 122 of 426 college students who completed a questionnaire on the history of ankle sprain were enrolled in healthy (n = 34; 24 men, 10 women; age = 20.6 ± 0.5 years), coper (n = 49; 38 men, 11 women; age = 20.2 ± 1.2 years), and CAI groups (n = 39; 24 men, 15 women; age = 20.1 ± 1.1 years).

Main Outcome Measure(s): One examiner measured the ATFL delineation using ultrasound and anterior ankle displacement using a capacitance-type sensor device. The Cumberland Ankle Instability Tool was applied to assess pain and perceived instability.

Results: The ATFL was normal more frequently in the healthy group and abnormal more frequently in the CAI group ($\chi^2 = 18.45$, $P < .001$). Anterior ankle displacement was greater in the coper and CAI groups than in the healthy group (both, $P < .001$), but no difference was observed between the coper and CAI groups ($P = .16$). We observed no correlation between the anterior ankle displacement and Cumberland Ankle Instability Tool scores ($r = -0.004$, $P = .71$) in participants with previous ankle sprains.

Conclusions: Observation of an abnormal ATFL on ultrasonography was associated with anterior displacement of the ankle joint. However, the influence of anterior ankle displacement due to damage to the ATFL on the pain and perceived instability in CAI was assumed to be small.

Key Words: ankle injury, anterior drawer test, pain, ultrasonography

Key Points

- Patients with chronic ankle instability (CAI) experienced symptoms such as pain and instability due to repeated ankle sprains.
- Patients with CAI more frequently had abnormal anterior talofibular ligaments and greater anterior ankle displacement compared with healthy individuals.
- Anterior talofibular ligament injury increased anterior ankle displacement but may have had a small influence on pain and disability in copers and patients with CAI.

Lateral ankle ligament injuries are among the most frequently occurring injuries during sports and physical activities.[1,2] Up to 70% of the general population experiences an ankle injury during their lifetime.[3] Ankle sprains have a high recurrence rate, and repeated ankle sprains can lead to chronic ankle instability (CAI) with residual symptoms such as pain and instability. Chronic ankle instability contributes to ankle osteoarthritis as a terminal outcome, as well as cessation of sports and physical activities, leading to longer-term health issues.[4]

Ankle sprains result in injuries to the soft tissue, including the ligaments, articular cartilage, and tendons.[1,2] Repeated ankle sprains result in the accumulation of damage to these periarticular tissues, causing a variety of functional impairments, such as limited joint range of motion and balance impairment.[5] In several studies, researchers using self-assessment results, including the Cumberland Ankle Instability Tool (CAIT) and the Foot and Ankle Ability Measure, have reported instability, pain, and decreased foot and ankle-joint function in patients with CAI, many of whom have long-term health problems.[6,7]

The anterior talofibular ligament (ATFL) is the most likely region to be injured in ankle sprains.[8] Anterior talofibular ligament injuries may cause anterior instability of the ankle joint,

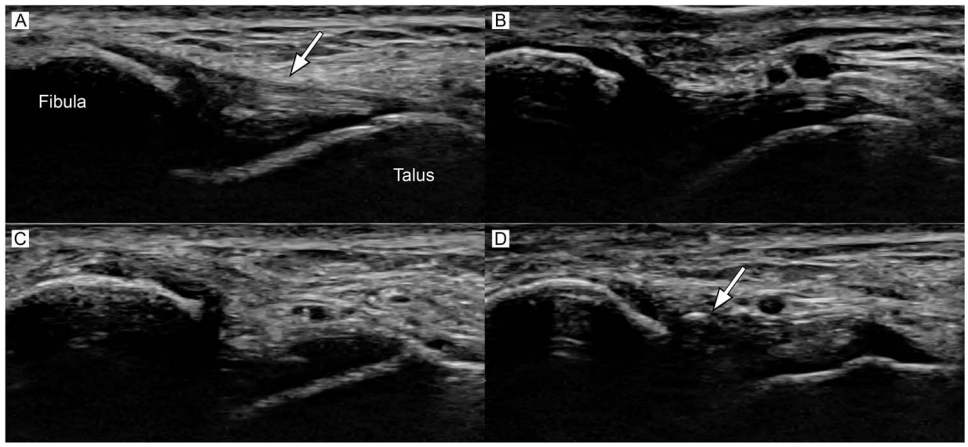

Figure 1. Classification of an anterior talofibular ligament. A, Normal ligament (arrow). B, Laxity of the ligament. C, Loss of the ligament. D, Avulsion fracture of the lateral malleolus without continuity. Arrow indicates bone fragment.

leading to impaired ankle kinematics and balance.[5,9] Although these dysfunctions can be improved by nonoperative therapy, improving pain and instability caused by structural damage resulting from ligamentous injuries is often difficult. Patients with residual instability may be required to cope with CAI through lifelong use of bracing, avoidance of sports activities, rehabilitation, and use of nonsteroidal anti-inflammatory drugs.[1,2]

Patients who do not improve with conservative treatment may be indicated for ligament reconstruction; however, patients with asymptomatic ankle anterior displacement (termed *copers*) are common.[10,11] The extent to which anterior ankle displacement is associated with pain and perceived instability in patients with CAI remains unclear.

The purposes of our study were to investigate the prevalence of ATFL injury in individuals classified as healthy, copers, and having CAI and to examine the influence of anterior ankle displacement on symptoms in patients with a history of ankle sprains. We hypothesized that anterior ankle displacement resulting from ATFL injury would be associated with pain and perceived instability in copers and patients with CAI.

METHODS

Participants

A power analysis with an α error of .05, power of 0.95, and effect size of 0.40, based on a previous study in which anterior ankle displacement was compared between intact ankles and ATFL-transected ankles, was performed using the G*Power 3.1.9.2 analysis software (Heinrich-Heine-Universität Düsseldorf).[12] This produced a minimum total sample size of 102. A questionnaire on the history of ankle sprain (Supplemental Figure, available online at https://dx.doi.org/10.4085/1062-6050-0582.23) was administered to 426 adult college students (852 ankles) recruited by email and flyers. Participants included athletes and those at the recreational activity level; the sports activity level was self-reported orally. Based on the questionnaire results, participants with no history of ankle sprains in either ankle were assigned to the healthy group. Next, among participants who had a history of ankle sprain and met the International Ankle Consortium–recommended diagnostic criteria for CAI, those with a CAIT score $\geq$25 points and no symptoms within the 12 months before the study were assigned to the coper group, and those with a CAIT score $\leq$24 points were assigned to the CAI group.[3,13,14] The CAIT includes 9 questions investigating ankle-joint pain and instability during physical activity, with lower scores on the 30-point scale indicating greater pain and perceived instability.[3] It was used only for participants with previous ankle sprains. For healthy individuals, the left or the right foot was randomly selected for testing. For patients who had a history of bilateral ankle sprains or CAI, the ankle with lower CAIT score was selected for testing.

A total of 149 individuals were enrolled in the healthy group, 62 in the coper group, and 64 in the CAI group. Of these, 122 individuals provided written informed consent: 34 healthy individuals (34 ankles), 49 copers (49 ankles), and 39 patients (39 ankles) with CAI. The study was approved by the ethics committee of Hokkaido Chitose College of Rehabilitation (CR17009).

ATFL Image

Participants underwent ultrasound imaging of the ATFL by a physical therapist (T.K.) who had at least 10 years of ultrasonic experience and was blinded to the group allocation, using a SONIMAGE HS1 SNiBLE (KONICA MINOLTA, Inc) and a linear probe (L18-4 Linear Array Transducer, KONICA MINOLTA, Inc). They were placed in a long sitting position with their feet extending beyond the edge of the bed, and the ATFL was scanned in both ankles. The probe was used to identify the anterolateral edge of the external capsule and anterolateral aspect of the talus along the ATFL, and still images were acquired.[15]

Anterior talofibular ligament injury or tear was determined by a single foot surgeon (A.T.) blinded to the group allocation and the side of injury. Based on the ultrasonography findings, ATFLs were classified as *normal* if no evidence of ligamentous damage was present and *abnormal* in case of any ligamentous discontinuity, hypoechoic findings, obvious laxity or swelling of the ligament, complete loss of the ligament, or an avulsion fracture of the lateral malleolus without continuity (Figure 1).[16,17]

Anterior Drawer Test

Anterior displacement of the ankle joint during the anterior drawer test was measured by a physical therapist (T.K.) who was blinded to the group allocation, using a capacitance-type sensor device (AT measure; Aimedic MMT). Previous

Figure 2. Anterior drawer test.

researchers have shown that this device has a high measurement reproducibility and a strong correlation with stress radiographs.[12] Participants' feet were fitted with a characteristic orthosis, and the capacitance-type sensor was attached to the ATFL. During the anterior drawer test, participants maintained a resting sitting position, with the ankle joint slightly plantarflexed. The examiner evaluated the amount of ankle-joint forward translation by pulling the calcaneus forward with 1 hand and pushing the tibia backward with the other hand (Figure 2).[18] The same procedure was performed 5 times on the same foot, and the value for each repetition was recorded. The average of 5 measurements was recorded as the anterior ankle displacement.

Statistical Analysis

First, normality was confirmed using the Shapiro-Wilk test for all data except the sex ratio and the determination of the ATFL. One-way analysis of variance with post hoc Tukey honestly significant difference test was used to compare age, height, and mass between groups, and the sex ratio was compared using the χ^2 test. The χ^2 test was further used to compare the percentages of normal and abnormal ATFLs between groups, and differences between groups were examined using adjusted residuals. One-way analysis of variance with post hoc Tukey honestly significant difference test was applied to compare anterior ankle displacement between groups. The correlation between the CAIT score and anterior ankle displacement in the coper and CAI groups was examined using Pearson product moment correlation coefficient. Independent *t* tests were performed to compare the CAIT score in participants with normal and abnormal ATFLs in the coper and CAI groups. Similarly, independent *t* tests were used to compare anterior ankle displacement in participants with normal and abnormal ATFLs among all groups. We used SPSS (version 25.0; SPSS) for statistical analysis, and statistical significance was set at <5%. Cohen d effect sizes were calculated to indicate the magnitude of the group differences. They were interpreted as *small* (d = 0.2), *moderate* (d = 0.5), or *large* (d = 0.8).[19]

Table 2. Anterior Talofibular Ligament Image Classification by Ankle Injury History

Classification	Healthy Group, No.	Coper Group, No.	Chronic Ankle Instability Group, No.	Total
Normal	30[a]	23	17	70
Abnormal	4	26	22[b]	52
Total	34	49	39	122

[a] Indicates a higher proportion of normal image classification (adjusted residuals, $P < .001$).
[b] Indicates a higher proportion of abnormal image classification (adjusted residuals, $P < .001$).

RESULTS

Physical Characteristics and ATFL Image

The healthy group was older than the other groups ($F_{2,119} = 4.891$, $P = .009$), but the sex ratio, height, and mass did not differ between the 3 groups (Table 1). More participants in the healthy group had normal ATFLs, and more patients in the CAI group had abnormal ATFLs ($\chi^2 = 18.45$, $P < .001$; Table 2).

Anterior Ankle Displacement and CAIT Score

Anterior ankle displacement differed across groups ($F_{2,119} = 15.317$, $P < .001$, d = 0.97). It was greater in the coper (7.63 ± 2.43 mm) and CAI (8.62 ± 2.95 mm; $P < .001$, d = 1.26) groups than in the healthy group (5.45 ± 1.92 mm), but no differences existed between the coper and CAI groups ($P = .12$, d = 0.37; Figure 3). We observed no correlation between anterior ankle displacement and CAIT score ($r = -0.004$,

Table 1. Participant Characteristics

Characteristic	Healthy Group	Coper Group	Chronic Ankle Instability Group	*P* Value
Sex, No. male/No. female	24/10	38/11	24/15	.30
Age, mean ± SD, y	20.6 ± 0.5[a]	20.2 ± 1.2	20.1 ± 1.1	.009
Height, mean ± SD, cm	167.2 ± 8.2	169.5 ± 8.3	166.9 ± 8.1	.17
Mass, mean ± SD, kg	59.9 ± 11.0	63.0 ± 7.8	63.2 ± 11.6	.13

[a] Participants in the healthy group were older than those in the coper ($P = .04$) and chronic ankle instability groups ($P = .02$; Tukey honestly significant difference test).

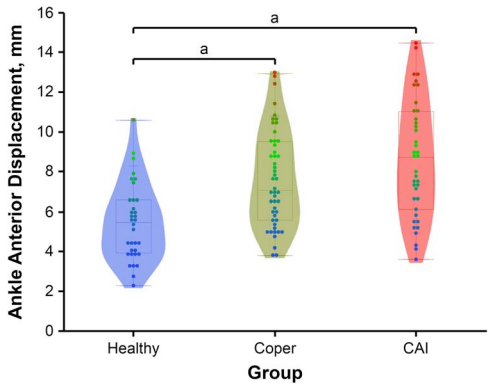

Figure 3. Comparison of anterior ankle displacement among the 3 groups. [a] $P < .001$. Data are presented as median (center horizontal line), interquartile range (box around the median), and spread of data (whiskers). Dots outside the box reflect outliers in the data.

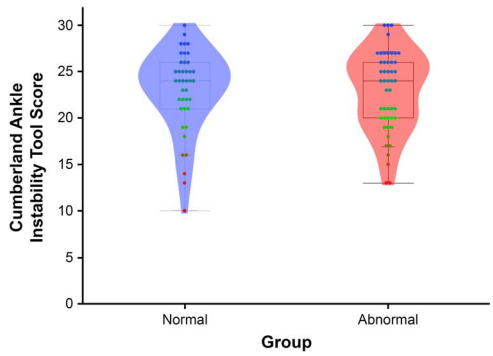

Figure 5. Comparison of Cumberland Ankle Instability Tool scores between the normal and abnormal anterior talofibular ligament image groups. Data are presented as median (center horizontal line), interquartile range (box around the median), and spread of data (whiskers). Dots outside the box reflect outliers in the data.

$P = .71$; Figure 4) and no difference in CAIT scores between the normal (22.95 ± 4.49) and abnormal (22.92 ± 4.35) ATFL groups in the coper and CAI groups ($t_{86} = 0.04$, $P = .97$, d = 0.01; Figure 5).

In contrast, anterior ankle displacement was greater in the abnormal ATFL group (8.69 ± 3.01 mm) than the normal ATFL group (6.34 ± 2.09 mm) in all participants ($t_{120} = -4.83$, $P < .001$, d = 0.89; Figure 6).

DISCUSSION

Measurements from 122 participants showed that the CAI group more frequently had abnormal ATFLs and greater anterior ankle displacement than the healthy group. In contrast, no difference in anterior ankle displacement was observed between the coper and CAI groups, and no correlation between pain and perceived instability was found based on CAIT scores and amount of anterior ankle displacement in the coper and CAI groups. Moreover, in the coper and CAI groups, CAIT scores were not different between the normal and abnormal ATFL groups. We observed a weak association between the anterior ankle displacement and pain or perceived instability in patients who had a history of ≥1 ankle injuries.

In a systematic review, Cao et al reported that ultrasound has high accuracy in the diagnosis of chronic lateral ankle ligament injuries.[20] In our study using ultrasound, more patients in the CAI group had an abnormal ATFL compared with patients in the healthy group. Similarly, more than half of the participants in the coper group had abnormal ATFL findings. This result is similar to those reported in previous studies on CAI, and it is likely that many patients with CAI and copers have ATFL dysfunction due to repeated ankle sprains.[10,11]

In our study, the CAI and coper groups had greater anterior ankle displacement than the healthy group. In a previous study in which stress ultrasound was used to measure the amount of the anterior drawer of the talus, the CAI and coper groups showed greater anterior ankle displacement than the control group.[21] We observed that the group with abnormal ATFL had greater anterior ankle displacement than the group with normal ATFL, suggesting that the CAI and coper groups included more cases of abnormal ATFL and greater anterior ankle displacement. Anterior talofibular ligament injuries and abnormal talar kinematics, such as excessive anterior translation and internal rotation, are closely related and are thought to be associated with symptoms in patients with previous ankle sprains.[9,22] However, in our study, we observed no difference in anterior ankle displacement between the CAI and coper groups. In previous studies, researchers reported no differences between the CAI and coper groups, which agrees with the results of our study.[23,24] In a study examining the correlation between anterior ankle displacement measured using a joint arthrometer and the CAIT score, Hirai et al found no correlation between the CAIT score and the amount of anterior

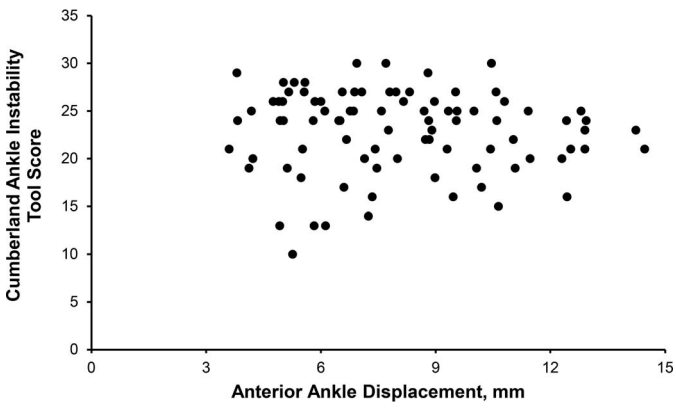

Figure 4. Relationship between the Cumberland Ankle Instability Tool score and amount of the anterior ankle displacement.

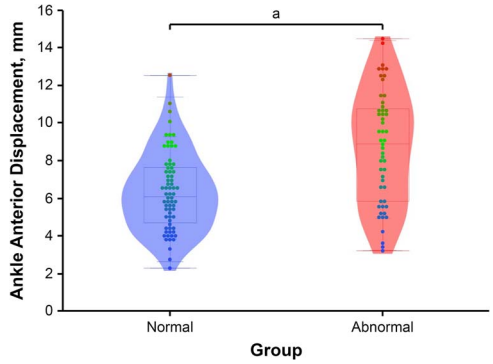

Figure 6. Comparison of the anterior ankle displacement between the normal and abnormal anterior talofibular ligament image groups. [a] $P < .001$. Data are presented as median (center horizontal line), interquartile range (box around the median), and spread of data (whiskers). Dots outside the box reflect outliers in the data.

ankle displacement.[25] These results suggest that anterior ankle displacement caused by ATFL injury is not correlated with symptoms such as pain and instability in patients with CAI.

Clinically, patients with CAI have a higher positivity rate in the talar tilt test than copers.[26] Patients with CAI who require surgery often present with calcaneofibular ligament and ATFL damage, which results in ankle-joint instability.[27] Furthermore, some patients with CAI exhibit damage to the ligaments associated with subtalar joint stability.[28,29] In our study, anterior ankle displacement was not related to pain and perceived instability in copers and patients with CAI; therefore, the relationship between medial and subtalar joint instability and symptoms in patients with ankle sprain should be investigated. The results of our study indicated that anterior ankle displacement in patients with CAI may be compensated by improving periarticular functions such as muscle strength, range of motion, and balance function, which can lead to coping. In contrast, in the treatment of patients with CAI who have severe pain and perceived instability, the presence of ligament injuries other than ATFL injuries and functional instability should be considered. Further studies are needed to clarify the association between other ligament injuries and CAI symptoms.

Our study had several limitations. First, ATFL injury was determined using ultrasonography and was not directly confirmed using arthroscopy or other means. However, the sensitivity and specificity of ultrasonography for ATFL injuries have been reported to be very high, and the determination in this study was also likely highly accurate.[20] Second, participants were limited to college students, and the results may be different when examining middle-aged patients and patients older than 65 years. Third, CAIT was not performed in the healthy group, so the results regarding the relationship between ATFL injury and anterior ankle displacement and CAIT were in a population with a history of ankle sprain.

CONCLUSIONS

Anterior talofibular ligament injury increased anterior ankle displacement but may have had a smaller influence on pain and perceived instability in copers and patients with CAI. The influence of anterior ankle displacement due to damage to the ATFL on pain and perceived instability in patients with CAI is assumed to be small.

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SUPPLEMENTAL MATERIAL

Supplemental Figure. IAC Criteria Questionnaire.

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