# Chronic lateral instability of the ankle

## Roentgen stereophotogrammetry of talar position

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Using roentgen stereophotogrammetric analysis (RSA), we investigated the talar mobility in 54 ankles during the anterior drawer and adduction tests. Talar tilt was increased in ankles with unilateral symptoms of chronic lateral instability. No other difference in talar tilt and anterior drawer sign was noted comparing ankles with and without symptoms.

We conclude that mechanical tests cannot always verify the diagnosis "chronic lateral instability of the ankle".

Chronic lateral instability of the ankle joint is defined as a condition with frequent sprains, difficulties in walking and running on uneven ground, and sometimes pain (1-3). Mechanical instability of the ankle or the subtalar joints (4,5), muscle weakness (6-8), subtalar adhesions (9), or proprioceptive defects (8, 10-12) may be of etiologic importance in these cases. Some authors (13-15) have focused on the varus instability of the talus (talar tilt), whereas others (16-20), have used the anterior laxity of the talus to document the mechanical instability.

The concept of anterolateral instability of the ankle was introduced after in vitro studies (20-24) and indicated that the talus not only displaced anteriorly, but also rotated internally, when subjected to an anteriorly directed force.

Staples (6), Hansen et al. (25), and Termansen et al. (7) found no correlation between remaining mechanical instability and residual symptoms after ankle sprains. Schweigel et al. (26) stated that no single test is conclusive concerning chronic lateral instability of the ankle.

Because the importance of the mechanical component is controversial, we recorded both the anterior talar displacement and the adduction stability in patients with chronic lateral instability of the ankle.

## Patients and methods

Twenty-nine patients (21 men, 8 women, mean age 30 [16-54] years) referred to the University Hospital in Umeå, Sweden, because of chronic lateral instability of the ankle were included. The mean duration of symptoms was 8 years. All of them were scheduled to be operated on. Totally, 54 ankles were studied; four ankles previously operated on were excluded.

The patients were informed about the purpose of the study, and all of them consented to the implantation of bone markers. Three to five tantalum balls with a diameter of 0.5 mm or 0.8 mm were implanted in the distal tibia and the talus. The implantation of the markers was performed with the aid of fluoroscopy under local anesthesia.

Because of difficulties in detecting the tantalum balls with a diameter of 0.5 mm located in the talus, seven of the radiographs could not be evaluated. In the latter part of the study, 0.8 mm tantalum balls and grids were used to overcome this problem.

Three to four weeks after the implantation of the tantalum markers, the patients were examined using roentgen stereophotogrammetric analysis (RSA) (27). With the patient in the supine position, the knee was flexed to about 15° and the foot was placed in a Plexiglass® calibration cage, which defined the three-dimensional laboratory coordinate system. The ankles were anesthetized (2-4 ml of Citanest® 0.5 percent in the talocrural joint) before the examination. Two si-

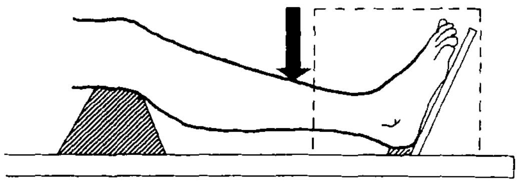

Figure 1. Posterior load of the tibia with the foot in the calibration cage. A posteriorly directed force was applied 20 cm proximal to the ankle by two weights attached to each end of a movable bar connected to the lower leg.

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multaneous exposures were made with the foot in the following positions: neutral, 30° plantar flexion under manual adduction and 10° plantar flexion; unloaded, with a posterior load of the tibia at 40 N and finally at 160 N.

When in the neutral position, the foot was placed in a plastic splint, which secured an angle of 90° between the lower leg and the sole of the foot. The ankle was oriented according to a standardized position in relation to the laboratory coordinate system (28).

Using another splint with the foot in 10° of plantar flexion, exposures were made without a load, as well as with loads applied to the lower extremity 20 cm proximal to the medial malleolus.

The adduction tests were performed by using lead protection gloves holding the foot in maximal adduction. The lower leg was placed somewhat laterally and the heel as distally as possible to ascertain a free mobility of the foot. For comparison, 14 ankles were examined using a specified torque (5 Nm) applied to a specially designed shoe (Figure 2).

During the testing procedure the degree of plantar flexion was not controlled, but the ankles were allowed to obtain a position that provided the least resistance. This resulted in a plantar flexion in all the groups (median 24–31°).

The radiographs were evaluated using a measuring table linked to a coordinatograph (Wild, Heerbugg, A7Z, Switzerland). The two-dimensional coordinates of cage and patient markers were further processed in a computer, enabling the calculation of the three-dimensional position of each tantalum ball in relation to the laboratory coordinate system at each position of the ankle.

All the talar rotations and translations were measured in relation to the neutral position using the tantalum balls in the distal tibia as the fixed reference segment. To obtain comparable talar translations, a central point was plotted on the AP and lateral views of the talus at the neutral position of the ankle (Figure 3). The central point was transferred to all the other talar positions by using the three-dimensional configuration of the tantalum balls in the talus (point transfer in the KINEMA program) (29).

The accuracy of roentgen stereophotogrammetric analysis has been calculated at 30–50 micrometers and 0.2°, respectively (27,30). For statistical analysis (Wilcoxon's rank sum test), the ankles were divided into four groups (Table 1).

Table 1. Chronic lateral instability of the ankle. Patient series

| Group | Symptoms | Side | Number of ankles |
|---|---|---|---|
| A | Without | L or R | 15 |
| B | Unilateral | L or R | 15 |
| C | Bilateral | L | 11 |
| D | Bilateral | R | 13 |

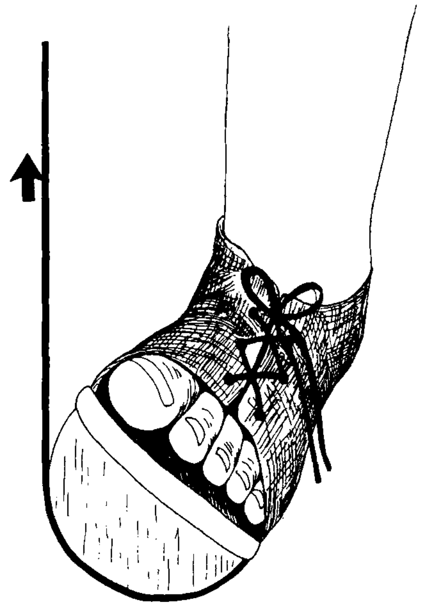

Figure 2. Adduction test 5 Nm. The foot was placed in a shoe with a cord attached laterally. The cord was running medially and then proximally to a pulley attached to the edge of the examination table.

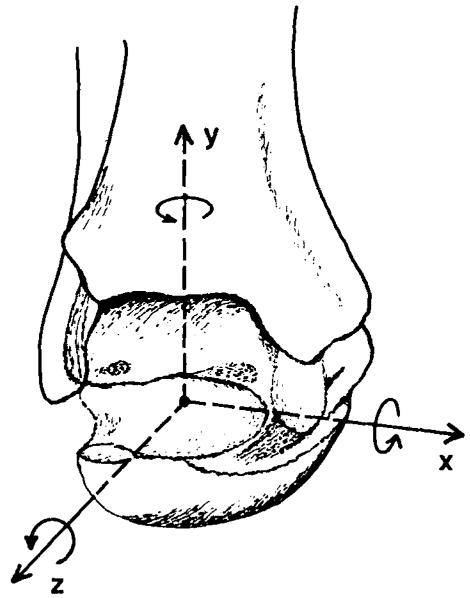


Figure 3. The coordinate system in the ankle joint. Talar translation was measured from a central point corresponding to the origin of the coordinate axes.

## Results

The reproducibility of the different loads was assessed by repeated examinations in five ankles. The standard deviations of the rotations about the transverse, longitudinal, and sagittal axes were 5.1°, 1.9°, and 2.4°; and the corresponding translations were 0.2, 0.2, and 0.5 mm.

### Adduction

Manual adduction of the foot caused internal rotation of the talus in all the groups (Table 2). The ankles with symptoms (groups B–D) had an adduction of 5.6–9.9° (median), whereas the ankles without symptoms (Group A) had an adduction of 4.1°. Ankles with unilateral symptoms (Group B) had increased adduction as compared with ankles without symptoms (Group A).

A correlation coefficient of 0.9 was obtained when comparing talar tilt tested manually and with a torque of 5 Nm.

### Posterior tibial load

The talus rotated slightly about the cardinal axes (median value 0.0–2.8°) at posterior loading of the tibia (Table 3). Both plantar flexion and dorsiflexion were observed, as well as internal and external rotation. Both asymptomatic (Group A) and symptomatic left ankles (Group C) showed a small abduction, whereas the other two groups displayed a small adduction. At a posterior tibial load of 40 N, there was a forward (0.5–1.3 mm) and distal (0.3–0.4 mm) translation of the talus in all the groups (Table 4). All the groups had a tendency towards medial translation.

Increasing the sagittal load to 160 N caused a minor

Table 2. Talar rotation (degrees) in relation to the tibia during manual adduction test. Median (range)

| Group | n | Plantarflexion | Rotation, int. +, ext. – | Adduction |
|---|---|---|---|---|
| A | 14 | 24 (16–45) | 2.3 (–11–15) | 4.1* (–3.2–10) |
| B | 14 | 25 (13–49) | 0.5 (–18–14) | 9.9* (–1.2–21) |
| C | 10 | 26 (9.6–39) | 2.3 (–3.9–9.8) | 5.7 (–1.5–16) |
| D | 12 | 31 (2.1–40) | 2.5 (–4.7–15) | 5.6 (0.0–31) |

Significant difference: * A–B $P<0.05$

Table 3. Drawer test. Talar rotation (degrees) in relation to the tibia at posterior loading of the tibia at 40 N. Median (range)

| Group | n | Flexion plant. +, dor – | Rotation, int. +, ext. – | Adduction + abduction – |
|---|---|---|---|---|
| A | 13 | –0.7 (–9.5–8.9) | 0.6 (–3.0–5.8) | –0.6* (–2.4–0.7) |
| B | 13 | –0.5 (–5.5–5.2) | 1.1 (–3.9–6.1) | 0.4* (–1.5–4.8) |
| C | 8 | 2.8 (–1.2–6.2) | 0.2 (–1.6–6.8) | –0.4 (–3.9–2.8) |
| D | 11 | 0.0 (–4.1–12) | 1.6 (–6.6–3.8) | 0.0 (–1.6–2.7) |

Significant difference: * A–B $P< 0.05$

Table 4. Drawer test. Talar translation (mm) in relation to the tibia at posterior loading of the tibia at 40 N. Median (range)

| Group | n | Medial + | Distal – | Anterior + |
|---|---|---|---|---|
| A | 13 | 0.1 (–0.4–0.7) | –0.4 (–1.6–0.1) | 0.5 (0.1–3.5) |
| B | 13 | 0.2 (–4.0–0.7) | –0.5 (–1.9–0.0) | 1.3 (0.1–8.9) |
| C | 8 | 0.3 (–0.1–1.6) | –0.3 (–0.5–0.7) | 0.8 (–0.2–6.7) |
| D | 11 | 0.0 (–0.7–1.5) | –0.3 (–2.0–0.1) | 1.2 (0.3–8.1) |

Table 5. Drawer test. Talar rotation (degrees) in relation to the tibia at posterior loading of the tibia at 160 N. Median (range)

| Group | n | Flexion plant. +, dor, – | Rotation int. +, ext. – | Adduction + abduction – |
|---|---|---|---|---|
| A | 12 | –0.2 (–11.3–7.6) | –0.7 (–9.4–5.2) | 0.3 (–2.0–2.9) |
| B | 12 | –1.8* (–13.7–7.3) | –2.4 (–7.8–3.4) | –0.2 (–2.1–7.9) |
| C | 8 | 1.2 (–3.7–14) | –0.5 (–3.8–5.3) | –0.5 (–4.2–2.1) |
| D | 8 | 1.5* (–6.3–17.2) | 2.1 (–5.0–14) | –0.5 (–4.8–7.2) |

Significant difference: * B–D $P < 0.05$

Table 6. Drawer test. Talar translation (mm) in relation to the tibia at posterior loading of the tibia at 160 N. Median (range)

| Group | n | Medial + | Distal – | Anterior + |
|---|---|---|---|---|
| A | 12 | 0.3 (–0.4–1.4) | –0.8 (–2.2–0.3) | 2.4 (0.3–6.3) |
| B | 12 | 0.3 (–1.9–1.6) | –1.2 (–2.0–0.1) | 4.6 (0.6–9.9) |
| C | 8 | 0.2 (–1.1–3.5) | –1.1 (–2.0–0.5) | 3.6 (1.4–6.3) |
| D | 8 | 0.3 (–0.8–4.2) | –0.9 (–2.5–0.3) | 3.6 (0.7–8.2) |

external rotation of the talus in most ankles (Table 5). The median talar translations were larger in all the groups at 160 N when compared with at 40 N, especially along the sagittal axis. No differences were found between the groups (Table 6).

## Discussion

Many technical devices have been designed to document varus instability of the talocrural joint (5, 13,31–33), making a strict comparison difficult. Rubin and Witten (13) stated that normal talar tilt (the angle between the tibial and talar joint surfaces) ranged from 0° to 23° with a force of about 50 N applied to the lateral part of the ankles. Using manual adduction, Brand et al. (2) found a talar tilt of 10° or greater in 14 percent of 175 healthy men. Cox and Hewes (34) measured talar tilt on conventional radiographs and found a maximum of 16° in a series of 404 manually tested ankles without a previous history of injury. Laurin et al. (5) stated that physiologic or normal talar tilt was easily demonstrated without excess force. They found no difference in talar tilt obtained by manual stress or by a stress apparatus. In our study the adduction tests were performed manually in all the patients, and in 14 ankles also by using a specified torque of 5 Nm. The high correlation coefficient (0.9) and the tests of reproducibility suggested that manual adduction could be performed with a rather constant torque in different patients and on various occasions in one and the same patient.

In the above-mentioned studies, the talar tilt was measured from conventional radiographs ignoring the accompanying rotations of the talus about the transverse and longitudinal axes. Rasmussen and Tovborg-Jensen (23) showed in a cadaver study that the talar tilt was most pronounced in the neutral position. A torque about one of the cardinal axes may induce rotations about all three cardinal axes, indicating that a rotatory joint instability is not limited to one of these axes (35). Therefore some authors (36) advocate unconstrained tests. As an effect of an unconstrained torque in our study, the talus rotated into plantar flexion and internal rotation when the adduction test was performed. Thus, if the amount of plantar flexion could be set at a more constant value in this study, a better separation between the groups might have ensued.

Increasing the posterior load of the tibia caused a greater anterior displacement of the talus in all the ankles. Ligamentous tissues allow some joint displacement with relatively little effort, but provide increasing resistance as the deformation increases (37). The maximal load applied directly to the anterior talofibular ligament until rupture of this ligament is about 140 N and for the calcaneofibular ligament 345 N (38). Even at long-term evaluation, ligament scars show mechanical abnormalities (37), as well as altered structural properties, with increased deformation under a lower load. At the load of 40 N, we found an insignificant tendency towards greater anterior displacement of the talus in symptomatically unstable ankles compared with the nonaffected ankles. Increasing the posterior tibial load to 160 N resulted in a leveling between the groups.

This could be an effect of changed stiffness of the previously injured ligaments, which was more easily demonstrated at a smaller load.

Freeman et al. (9) introduced the concept of functional instability of the foot (subjective feeling of the foot tending to give away) based on 14 of 45 patients complaining of persistent varus instability without showing any clinical or radiographic abnormality.

Half of our patients had bilateral symptoms with a mean duration of symptoms of 8 years. The stress tests did not show any difference (excluding plantar flexion at 160 N) when comparing ankles with bilateral symptoms (Groups C and D) and those with no or unilateral symptoms (Groups A and B). This indicates that especially the group with bilateral symptoms might have a different etiology (such as subtalar instability, muscular weakness, or proprioceptive defects) than a mechanical instability of the talocrural joint to their ankle symptoms.

In conclusion, mechanical instability of the talocrural joint could not be demonstrated in all our cases with symptoms of chronic lateral instability.

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## Acknowledgements

This study was supported by grants from Ingabritt and Arne Lundberg's stiftelse, Nordiska samfundet för vetenskap utan djurförsök, the Medical Research Foundation (MFR 1387–17x–07941–01A), LIC-Orthopedic, Riksförbundet mot Reumatism, and the Faculty of Medicine, University of Umeå.