

DISTAL TIBIOFIBULAR LIGAMENTS

Analysis of Function

OVE RASMUSSEN, IB TOVBORG-JENSEN & SVEND BOE

Laboratory of Biomechanics, Orthopaedic Hospital, Århus, Denmark

The function of the anterior tibiofibular ligament, of the syndesmosis between the distal parts of the tibia and fibula, and of the posterior tibiofibular ligament was elucidated by tracing mobility patterns before and after successive ligament transection in varying sequence. Eighteen osteoligamentous preparations were studied. Mobility was only minimally influenced by isolated cutting of the anterior tibiofibular ligament, and even complete cutting of the distal tibiofibular ligaments involved only minor abnormality in motion. However, external rotation was greatly increased by further cutting of the anterior part of the deltoid ligament or of the posterior talofibular ligament. This indicates that isolated injury of the anterior tibiofibular ligament must be rare, and total rupture of the distal tibiofibular structures is presumably as a rule combined with lesions of the anterior part of the deltoid ligament and/or of the posterior talofibular ligament.

Key words: ankle joint; ligaments articular

Accepted 31.i.82

The anterior tibiofibular ligament (ATFL), the syndesmosis, and the posterior tibiofibular ligament (PTFL) connect the distal parts of the tibia and fibula. Parts of this ligamentous apparatus, in particular the ATFL, are said, at times, to sustain isolated rupture (Lauge-Hansen 1942, Bonnin 1950, Broström 1964) or to rupture in association with more extensive damage (Lauge-Hansen 1942, Weber 1966).

Close (1956) has demonstrated that the attainable external rotation of the talus gradually increases when the distal tibiofibular structures are cut successively in the antero-posterior direction. Also the mortise can widen and the talus be displaced laterally, which entails diminished area of contact between the tibia and the talus (Ramsay & Hamilton 1976), with the risk of secondary

osteoarthritis. Thus, the ATFL, the syndesmosis and the PTFL appear to be essential to the stability of the ankle and thereby to weight transmission and walking function.

The present study was undertaken to elucidate in detail the role of these structures in ankle stability and the mechanisms which may cause their rupture.

MATERIALS AND METHODS

Mobility, and thereby stability, in the ankle joint was measured by an apparatus which enables recording of rotation in the ankle joint in two planes simultaneously when the talus is exposed to a well-defined torque.

This apparatus (Figure 1) consists of a lever provided with strain gauges in two planes at right angles to each other. This lever is connected mechanically to two potentiometers which measure rotation in the same two planes. Signals from the strain gauges and potentiometers pass through an amplifier unit and then to two potentiometer recorders (one of which records the tor-

Aided by grants from the Danish Medical Research Council, project no. 12-2109 and the Foundation for Classic Clinical Research, Århus University.

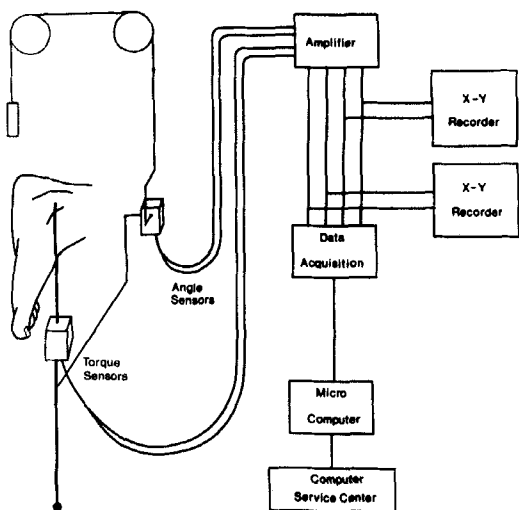


Figure 1. Schematic diagram of the experimental set-up.

que and the other a provisional mobility pattern) and at the same time via a data acquisition system to a micro-computer (RC 702) which stores the measuring results on floppy disks. From here, the measuring results are later transmitted to a computer service centre (RECAU) which performs the final graphic recording of mobility in the form of mobility patterns.

The lever is mounted on a nail inserted into the talus, in a postero-anterior direction (Figure 2a) to record mobility in the sagittal + horizontal plane, or from below, through the calcaneus and up into the talus (Figure 2b) to depict mobility in the sagittal + frontal plane.

A torque of 1.5 Nm was selected. This is obtained by manually affecting the lever so that the torque recorder describes, with an oscillating motion, a square whose sides correspond to 1.5 Nm (Figure 3). Thereby the ankle joint is exposed to a torque of 1.5 Nm in the dorsal, plantar, lateral, as well as medial directions, and thus the mobility patterns are in fact composed of four curves. The computer selects those angulations which correspond to the torque chosen ± 10 per cent. At the final recording of the mobility, the computer service centre performs interpolation between the excursions found in any direction and smooths the curves.

The function of the ATFL, the syndesmosis, and the PTFL was studied in 18 osteoligamentous preparations, the mobility being recorded first with intact ligaments, and then after successive cutting of the structures in an antero-posterior direction or vice versa. In six preparations, furthermore, the posterior talofibular ligament (PTaFL) or the anterior part of the deltoid ligament was cut.

RESULTS

Figure 4a illustrates the findings in the sagittal + horizontal plane on successive cutting of the ATFL, the syndesmosis and the PTFL in the named sequence. At the top it gives dorsal flexion, at the bottom plantar flexion, laterally external rotation of the talus and medially internal ro-

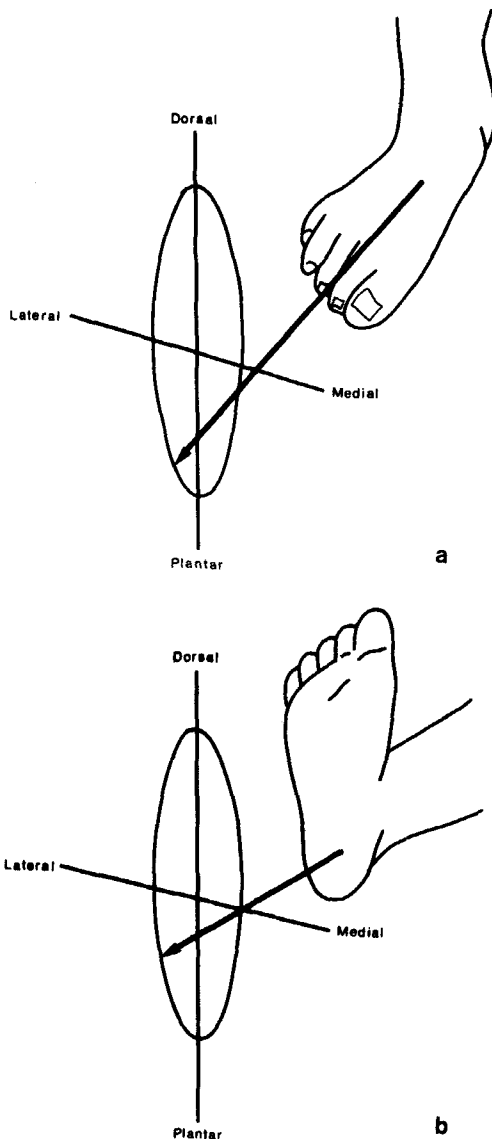


Figure 2. Lever in position for investigating mobility in the sagittal and horizontal planes (a) and in the sagittal and frontal planes (b).

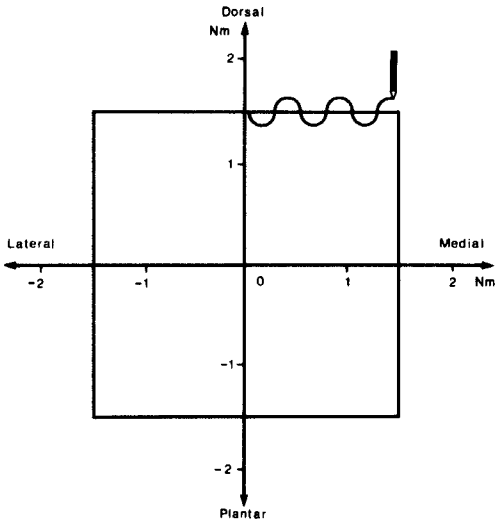
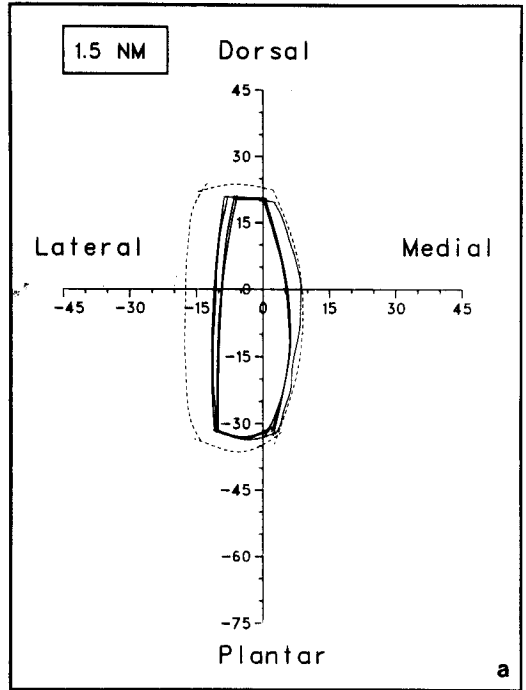


Figure 3. Torque square with sides corresponding to 2×1.5 Nm.



tation. This study was performed on five preparations.

Isolated cutting of the ATFL increases external rotation by 0.5° – 2.5° (mean 1.5°). On further cutting of the syndesmosis this rotation increases by a mean of 2.1° , and when the PTFL is also cut a further increase of 1° takes place. The total increase in external rotation after complete cutting was 3° – 5.5° (mean 4.6°). In one case internal rotation increased by 1° after cutting of the ATFL, while in the other four cases it did not increase until the PTFL had been cut, in that case by 3° – 5° (mean 4°).

The study was done in the sagittal + frontal plane on eight preparations (Figure 4b). In this

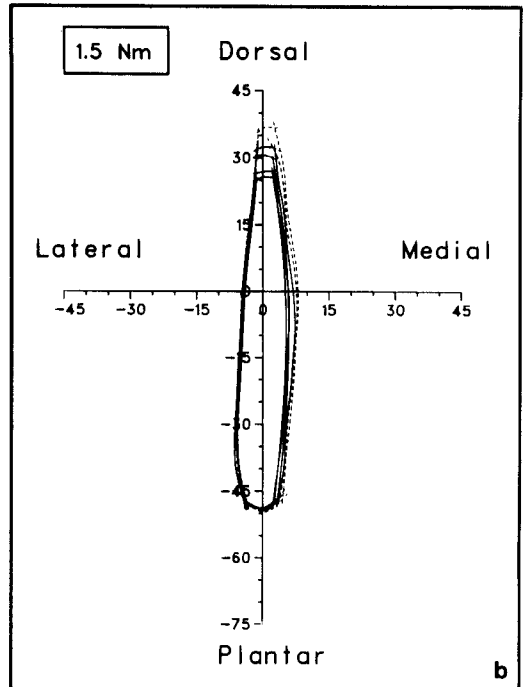


Figure 4a. Mobility patterns in the sagittal and horizontal planes. The most central recording depicts the mobility with intact ligaments; then, moving outwards, after cutting of the ATFL, then the ATFL + syndesmosis, then after cutting of the PTFL, and the outermost recording was made after cutting of the PTFL as well.

Figure 4b. Mobility patterns in the sagittal and frontal planes. The structures were cut in the sequence: anterior part of the deltoid ligament, ATFL, syndesmosis, PTFL, and PTFL.

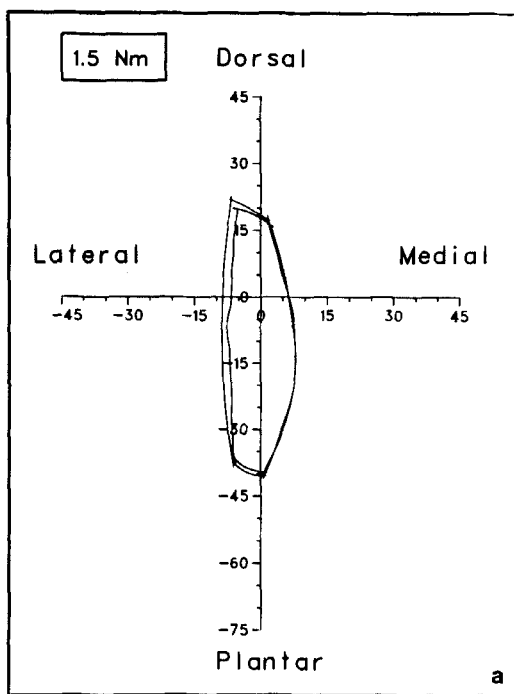
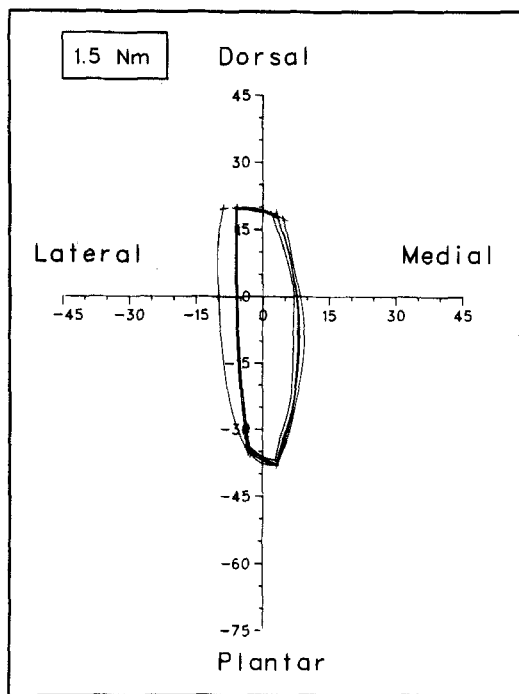


Figure 5. Mobility patterns in the sagittal and horizontal planes after successive cutting of the tibiofibular structures in the postero-anterior direction.

experimental set-up, movement in the medial direction expresses talar tilt or adduction of the hindfoot, in the lateral direction a negative tilt or abduction of the hindfoot. In these experiments the sequence of cutting the ligaments was of no importance, the mobility patterns remaining practically unchanged even after complete cutting.

In three preparations the distal tibiofibular structures were cut successively in a postero-anterior direction, and the mobility was recorded in the sagittal + horizontal plane (Figure 5). Isolated cutting of the PTFL did not alter external rotation, but increased internal rotation by about 1° . After the syndesmosis had also been cut, internal as well as external rotation increased by another 1° . Further cutting of the ATFL again increased internal rotation by 0.5° – 3.5° (mean 1.5°), so that after complete cutting the increase in internal rotation amounted to 3.5° . External rotation increased by less than 1° after cutting of

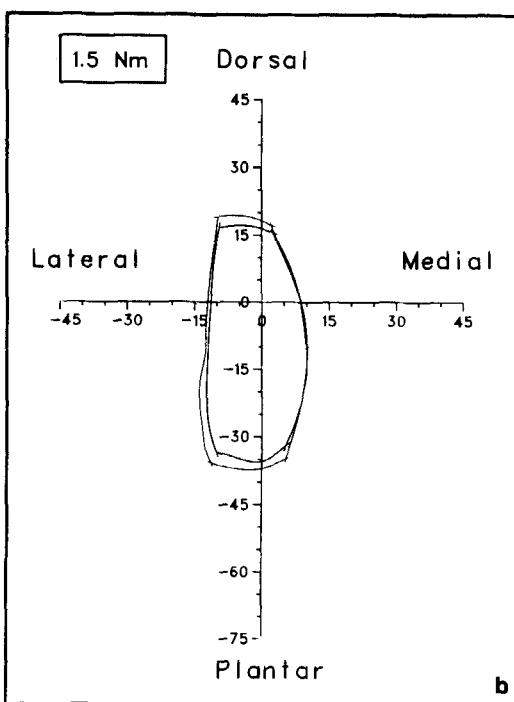


Figure 6. Sagittal and horizontal planes. The central recording describes the mobility with intact ligaments, the peripheral recording after cutting of (a) the PTFL and (b) the anterior part of the deltoid ligament.

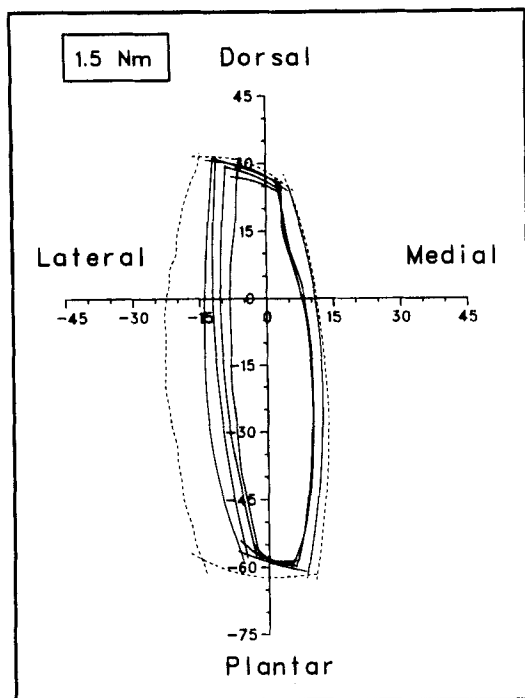


Figure 7. Sagittal and horizontal planes. Mobility after successive cutting of the tibiofibular structures in the antero-posterior direction. The most peripheral curve represents the mobility after also cutting the anterior part of the deltoid ligament.

the two posterior structures, and after complete cutting the external rotation was increased by a total of 3° – 5° (mean 4°).

Isolated cutting of the PTaFL or of the anterior part of the deltoid ligament caused practically no alterations in the mobility pattern in the horizontal plane (Figure 6a and b). But if such cutting was combined with complete cutting of the tibiofibular structures (Figures 4a and 7), there occurred an essential increase in external rotation, by 7° and 9° respectively. In the frontal plane, however, such cutting did not appreciably alter the mobility patterns (Figure 4b).

DISCUSSION

In the frontal plane Mullins & Sallis (1958) found an increased talar tilt after rupture of the syn-

desmosis. We could not demonstrate any major changes in the mobility in the frontal plane after transection of the tibiofibular ligaments, and consequently these ligaments are not likely to rupture in tilting of the ankle joint.

In the horizontal plane it is stated that the distal tibiofibular ligaments may rupture in external rotation traumas (Lauge-Hansen 1942, Bonnin 1950, Cedell 1967). We found that isolated transection of the ATFL caused an increase in external rotation by only about 1.5° . To produce an isolated rupture of this ligament, an external rotation trauma must be of quite special severity, i.e. severe enough to disrupt the strong ligament, and yet modest enough so that the somewhat weaker syndesmosis can prevent the abnormal movement from exceeding about 1.5° . This must be a rare occurrence.

Cutting of the entire distal tibiofibular ligamentous apparatus increased external rotation by only 4° – 5° . If the external rotation movement responsible for such rupture should exceed these few degrees, either the anterior part of the deltoid ligament, or the PTaFL, or both would also rupture (Figures 4a and 7).

This suggests that total rupture of the distal tibiofibular structures rarely occurs as an isolated lesion. Indeed, several authors (Staples 1965, Voutey 1971, Edeiken & Cotler 1978) have reported that rupture of the syndesmosis usually co-exists with rupture of the deltoid ligament, and Hönigschmied (1877) has even experimentally induced rupture of the syndesmosis together with rupture of the PTaFL by external rotation. Lauge-Hansen (1950) has described simultaneous tightening of the tibiofibular ligaments and of the PTaFL. Presumably the traction of the PTaFL often causes an avulsion fracture of the fibula instead of a ligament rupture, making the lesion identical to a stage 2 supination-external rotation fracture in the classification of Lauge-Hansen (1942).

Increased internal rotation was not found until the PTFL was cut. However, this ligament is much stronger than the anterior talofibular ligament which primarily inhibits internal rotation and which will probably be the first to rupture.

CONCLUSION

This investigation indicates that rupture of the distal tibiofibular structures may occur only in external rotation traumas. However, isolated rupture of the ATFL is probably extremely rare, and even when the entire distal tibiofibular ligamentous apparatus is injured, the probability of a simultaneous rupture of the anterior part of the deltoid ligament or of the PTaFL should be borne in mind.

REFERENCES

- Bonin, J. G. (1950) *Injuries to the ankle*. William Heinemann Medical Books Ltd., London.
- Broström, L. (1964) Sprained ankles I. Anatomic lesions in recent sprains. *Acta Chir. Scand.* **128**, 483–495.
- Cedell, C.-A. (1967) Supination-outward rotation injuries of the ankle. A clinical and roentgenological study with special reference to the operative treatment. *Acta Orthop. Scand.*, Suppl. 110.
- Close, J. R. (1956) Some applications of the functional anatomy of the ankle joint. *J. Bone Joint Surg.* **38-A**, 761–781.
- Edeiken, J. & Cotler, J. M. (1978) Ankle trauma. *Semin. Roentgenol.* **13**, 145–155.
- Hönigschmied, J. (1877) Leichenexperimente über die Zerreibungen der Bänder im Sprunggelenk mit Rücksicht auf die Entstehung der indirecten Knöchelfracturen. *Dtsch. Z. Chir.* **8**, 239–260.
- Lauge-Hansen, N. (1942) *Ankelbrud I. Genetisk diagnose og reposition*. Thesis, Munksgaard, Copenhagen.
- Lauge-Hansen, N. (1950) Fractures of the ankle II. Combined experimental – surgical and experimental – roentgenologic investigations. *Arch. Surg.* **60**, 957–985.
- Mullins, J. F. P. & Sallis, J. G. (1958) Recurrent sprain of the ankle joint with diastasis. *J. Bone Joint Surg.* **40-B**, 270–273.
- Ramsey, P. L. & Hamilton, W. (1976) Changes in tibiofibular area of contact caused by lateral talar shift. *J. Bone Joint Surg.* **58-A**, 356–357.
- Staples, O. S. (1965) Ligamentous injuries of the ankle joint. *Clin. Orthop.* **42**, 21–35.
- Voutey, H. (1971) Séquelles des entorses tibio-tarsiennes. *Rhumatol.* (March 1971), 9–32.
- Weber, B. G. (1966) *Die Verletzungen des oberen Sprunggelenkes*. Verlag Hans Huber, Bern und Stuttgart.

Correspondence to: Ove Rasmussen, Korshøjen 103, DK – 8240 Risskov, Denmark