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The Effect of the Syndesmotic Screw on the Extension Capacity of the Ankle Joint

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Summary. To investigate whether, when inserting a syndesmotic screw, the foot position effects the range of motion in dorsal extension, 16 osteoligamentous lower-leg preparations were studied. The specimens were placed in a test frame where a constant dorsal extension force could be applied to the foot. The dorsal extension capacity was recorded with a syndesmotic screw inserted by a standardized technique in various plantar flexion positions. The dorsal extension capacity decreased by an average of 0.1° for every degree of increase in plantar flexion when the screw was being inserted. There was a correlation between a large decrease in range of motion and a limited dorsal extension capacity to start with. No correlation could be found between a large decrease in range of motion and a large difference in width between the anterior and posterior edges of the talar trochlea. The results suggest that the foot should be in maximal dorsal extension when a syndesmotic screw is inserted in order to decrease the risk of stiffness.

A limitation in range of motion in dorsal extension is a not unusual complaint after ankle fractures [2, 8]. Many patients have this problem in spite of anatomical reduction, uneventful healing, and absence of osteoarthritis. The condition is very troublesome. Besides causing discomfort or pain, it limits the patient's ability to climb stairs and can also impair gait on even ground.

Viewing the talus from above, the talar trochlea seems wider anteriorly than posteriorly. According to some authors, this will lead to a widening of the syndesmosis when the foot is brought to dorsal extension [1, 4, 5, 7]. This is debated, however. Inman believes that the wedge shape of the talar trochlea is a misconception [7]. The talar trochlea is a fulcrum of a cone and the width of the trochlea measured parallel to the joint axis is equal anteriorly and posteriorly. Widening of the syndesmosis takes place during dorsal extension. However, the fibula is not immobile; it rotates and glides relative to the tibia. Several other authors agree with this concept [3, 10]. Yet another view is presented by Grath [6], who states that a widening does occur, but that it is of insignificant magnitude.

Several patients with limitation in range of motion have had a syndesmotic screw (own unpublished data). If the concept that the syndesmosis becomes wider towards dorsal extension is correct, a screw inserted with the foot in plantar flexion will lead to a limitation in range of motion due to impingement of the talus in the mortise. A syndesmotic screw would also prevent the fibula from preforming other motions. Any adjustment of the configuration of the mortise will be disturbed by a syndesmotic screw. A screw is therefore likely to affect the range of motion in the ankle joint.

This investigation was preformed to see whether the range of motion in dorsal extension depends on the position of the foot when the syndesmotic screw is inserted.

Material and Methods

Sixteen osteoligamentous preparations were taken from 16 cadavers. The specimens were exarticulated through the knee and metatarsophalangeal joints. No history or signs of injury or disease of the extremity were permitted. The dissections were performed within 1 day post mortem. The subjects were between 65 and 80 years old and had died of mainly cardiovascular diseases.

A test apparatus was constructed consisting of a steel frame 70 × 30 × 15 cm. Toward one end of the frame a wooden foot plate was attached in such a way that it could move freely around a vertical axis. Toward the other end of the

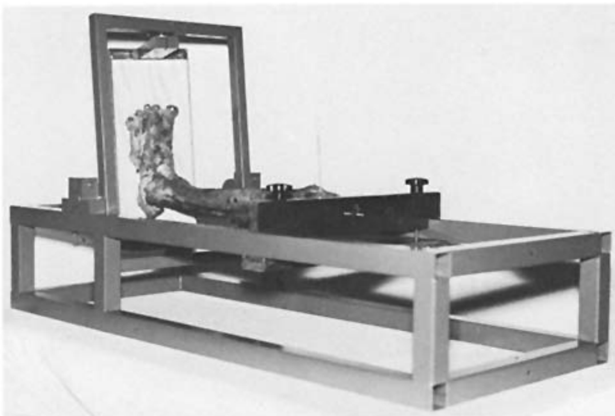


Fig. 1. The test frame with a specimen mounted. The foot of the specimen is screwed to the foot plate. A pin in the proximal end of the specimen is placed in a gliding hole of the frame to allow for free rotation and telescopic motion. The foot plate can move freely in dorsal extension and plantar flexion

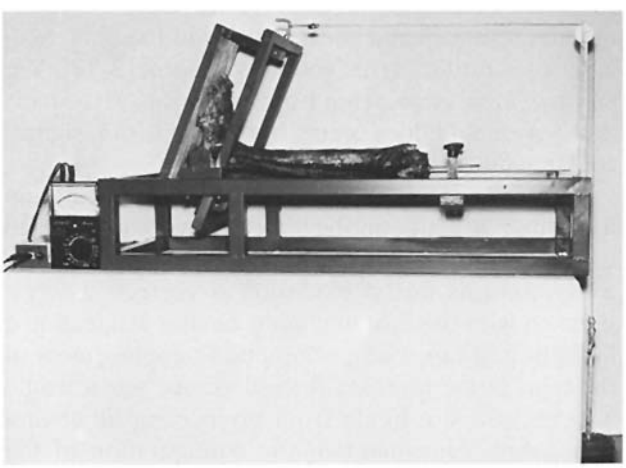
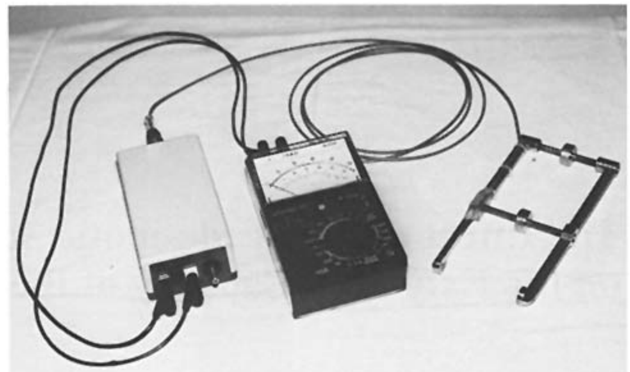
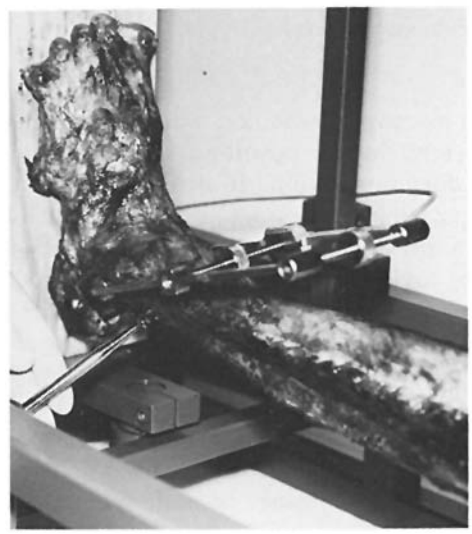


Fig. 2. A constant dorsal extension force can be applied to the specimen by means of a string and a weight



a



b

Fig. 3. a This device was used to get a constant compression force between the two malleoli when inserting the syndesmotic screw. The two arms of the device could be compressed by turning the screws. Strain gauges were glued to one arm and the compression force could be recorded using a voltmeter. **b** The device is attached to the specimen while the syndesmotic screw is being inserted

frame was a plate with a gliding hole. The foot of the specimen was screwed to the foot plate. A pin inserted in the proximal tibial joint surface was placed in the gliding hole. The foot screwed to the plate could thus be moved in plantar flexion and dorsal extension. The proximal tibial pin allowed the tibia to telescope freely and rotate in relation to the frame (Fig. 1). A constant dorsal extension force could be applied to the specimen by means of a string attached to the upper part of the foot plate. The string ran over a pulley and was loaded with a constant weight of 1 kg. Thus, the maximal dorsal extension capacity of each specimen could be measured as the angle between the foot plate and the frame in a standardized way (Fig. 2).

The maximal dorsal extension capacity was measured for each preparation without a syndesmotic screw and with a syndesmotic screw inserted with the ankle joint in various positions, from maximal dorsal extension to maximal plantar flexion. Four or five registrations were made with each specimen. The syndesmotic screw was inserted 4 cm proximal to the distal tibial joint surface. The screw holes were tapped in three cortices. For each registration a new hole was prepared as close as possible to the previous one without interfering with it. The four or five holes were thus placed within 1.5 cm of one another.

To enable a standardized insertion technique for the syndesmotic screw, an apparatus was constructed that could compress the malleoli with a constant force. It consisted of two arms that could be apposed to each other by means of screws. Strain gauges were glued to one arm and the compression force could be recorded with a voltmeter. The compression force used was 100 N (Fig. 3, a and b).

After the experiment the talus was dissected free in 15 of the specimens and the anterior and posterior width of the trochlea was measured. The difference in width was recorded.

Statistics

The equation of the straight line of the change in range of motion in dorsal extension with increased plantar flexion in insertion position was calculated for each specimen using the last-square method.

The mean slope and standard deviation were then calculated and compared with "0" using the t-test. The slope of each specimen was correlated to the maximal dorsal extension capacity, as well as to the difference in width of the talus.

Results

The maximal dorsal extension capacity is decreased if the syndesmotic screw is inserted with the foot in plantar flexion as compared with dorsal extension. The lines of the different specimens are plotted in Fig. 4. The decrease in dorsal extension capacity is on average 0.1° for every degree of plantar flexion in the insertion position (Fig. 5). The relationship is linear ($r = 0.86$); this decrease is strongly significant ($P < 0.001$).

There was a correlation between the slope and the maximal dorsal extension capacity of each specimen (Fig. 6). The coefficient of regression was 0.67. This

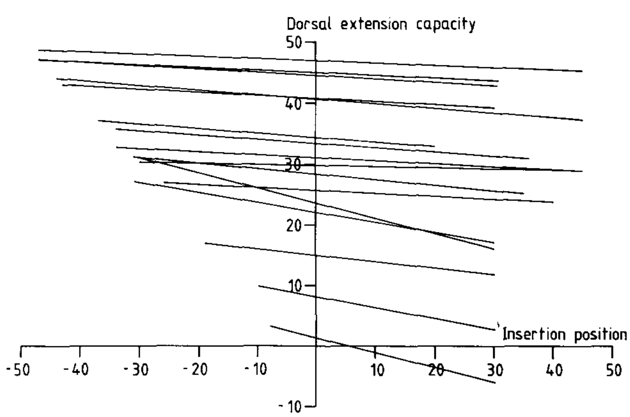


Fig. 4. The change in dorsal extension capacity with increased plantar flexion position when inserting the syndesmotic screw for the 16 specimens. The straight lines were calculated using the last-square method

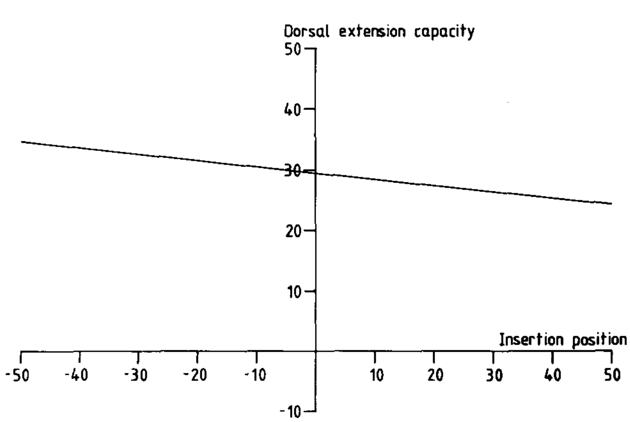


Fig. 5. The average change in dorsal extension capacity with increasing plantar flexion position when inserting the syndesmotic screw

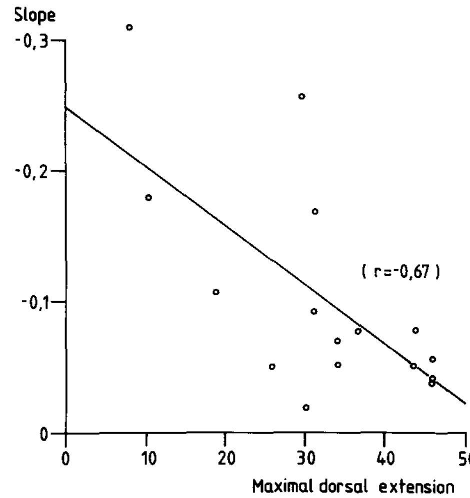


Fig. 6. The correlation between the slope and the maximal dorsal extension capacity without a syndesmotic screw for the 16 specimens. Note that the preparations with large dorsal extension capacities are less sensitive to the foot position when a syndesmotic screw is inserted than are those with a limited dorsal extension capacity

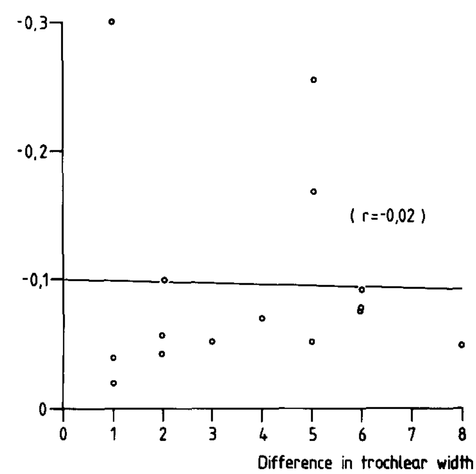


Fig. 7. The lack of correlation between the slope and the difference in width between the anterior and posterior edge of the talar trochlea

indicates that ankles with a smaller range of motion in dorsal extension are more sensitive to the foot position when the syndesmotic screw is being inserted than are those with a larger range of motion.

There was no correlation between the difference in width of the anterior and posterior parts of the talar trochlea and the decrease in dorsal extension capacity ($r = -0.02$; Fig. 7).

Discussion

The results of this investigation indicate that the position of the foot when the syndesmotic screws are being inserted has an important effect on the range of motion in dorsal extension.

The syndesmotic screw locks the fibula to the tibia. The mortise is thus prevented from adjusting to any demands of configuration change by the talar trochlea during dorsal extension of the foot.

The concept that the syndesmosis widens in dorsal extension of the ankle is controversial. Several authors state that the wedge shape of the trochlea must lead to a widening [1, 4, 5, 7]. Others claim that no significant or very limited widening occurs [3, 6, 7, 10]. However, most authors agree that some motions occur between the fibula and the tibia during dorsal extension.

The lack of correlation between the degree of limitation in dorsal extension and the difference in width of the anterior and posterior part of the talar trochlea contradicts the concept that the syndesmosis widens in dorsal extension. If this had been the case, one could have expected a stronger correlation. The more wedge-shaped trochleas would have had more limitation in dorsal extension and vice versa.

The results also contradict the idea that the mortise does not have to adjust to a configuration change of the trochlea during motion. This study indicates that some adjustments of the configuration of the mortise have to occur as the foot is moved from plantar flexion to dorsal extension; this has been suggested by Scranton et al. and Weber [9, 10].

In the studied specimens there was a correlation between the extent of decreased range of motion in dorsal extension and the maximal dorsal extension capacity. The preparations with a great range of motion to start with are not as sensitive to what position the foot is placed in when the syndesmotic screw is inserted as are those with initially limited range of motion. This indicates a variation in the anatomy. Those with a limited range of motion in dorsal extension seem to have a greater demand for motion between the fibula and the tibia for normal joint function. What this anatomical variation consists of is not answered by this study, nor are any suggestions to be found in the literature, as far as the author is aware. However, this fact clearly shows that there is a very great variation in detail in the functional anatomy of the human ankle joint. This has to be taken into account in ankle traumatology.

The limitation in range of motion due to the effect of the syndesmotic screw seems, however, to be too small to explain by itself the clinical problem of stiffness. One explanation might be the large interindividual variation noted. Patients who feel discomfort after syndesmotic screw fixation may have the anatomical features that put great demands on adjustment of the configuration of the mortise during ankle motion. The clinical problem with limited range of motion is probably also multifactored. Articular factors other than syndesmotic screw fixation that probably contribute are fibrosis and stiffness of the posterior capsule, and fibrosis and scarring of the fat pad located anterolaterally in the joint. Also, several extra-articular factors most certainly play a role, such as adhesion of tendons and contracture and fibrosis of the calf muscles.

Conclusions

The range of motion in dorsal extension is negatively affected if the syndesmotic screw is inserted with the foot in plantar flexion. The syndesmotic screw should therefore be inserted with the foot in maximal dorsal extension in order to minimize the risk of a limitation in range of motion.

A configuration change of the mortise occurs when the ankle joint is brought to dorsal extension. This configuration change is greater in ankles with a limited range of motion to start with than in ankles with a large range of motion.

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