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The Role of a Posteriorly Positioned Fibula in Ankle Sprain

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Background: Specific anatomic variations of the ankle mortise may predispose people to ankle sprains.
Hypothesis: There is a correlation between a higher malleolar index (posteriorly positioned fibula) and incidence of ankle sprain.
Study Design: Prospective case control study.
Methods: We compared the malleolar index (transverse plane of the talus) on computerized axial tomographic images of 61 patients with ankle sprain with that of 101 normal controls. A positive number for the malleolar index meant that the lateral malleolus was posterior to the plane of the medial malleolus. A negative number meant that the lateral malleolus was actually anterior to the plane of the medial malleolus.
Results: The average malleolar index of the patients with ankle sprain was +11.5° with a standard deviation of 7°. Malleolar relationships varied from –6° to +39°, a range of 45°. The average malleolar index in the control group was +5.85° with a standard deviation of 4.9°, which varied from –8° to +16°. However, there was no correlation between recurrence of sprains and malleolar index values.
Conclusion: Patients with an ankle sprain were more likely to have a posteriorly positioned fibula, possibly predisposing them to ankle sprain.

Ankle sprains are among the most common injuries in sports.[5,25] Previous studies have suggested underlying factors that may predispose people to ankle sprains; these risk factors can be classified as either extrinsic or intrinsic.[12] Extrinsic factors include training errors, type of sport, playing time, level of competition, equipment, and environmental factors. Intrinsic factors include anatomic variations, strength deficits, previous history of sprain, generalized joint laxity, sex, limited range of motion, and ankle inversion weakness.[2] In addition, other intrinsic factors such as the presence of proprioceptive and peroneal muscular deficiency also play a role in ankle sprains.[9,11,17,18]

Anatomic variations of the foot and ankle have been investigated in various studies examining the risk factors for ankle sprains. Varus tibial plafond or varus hindfoot has been described in association with recurrent sprains.[3,5,16,23,26] In a recent retrospective review of computed axial tomographic (CAT) scans of 100 consecutive patients, Scranton and associates[18] observed that patients with chronic ankle instability might have had a posteriorly positioned fibula relative to the medial malleolus, which was thought to predispose them to ankle sprains. The purpose of this study was to investigate prospectively the role of a posteriorly positioned fibula as one of the possible intrinsic risk factors for inversion ankle sprains. We also discuss some of the other intrinsic factors that may predispose people to ankle sprains.

MATERIALS AND METHODS

Sixty-one consecutive patients (35 women and 26 men) with acute ankle sprain were included in the study. The average age of the patients was 31.8 years (range, 16 to 69; SD, 12.2). The clinical evaluation was made on the basis of the history, physical examination, and radiographs (AP, lateral, mortise, and axial calcaneal views) by the authors. Functional treatment was initiated before the patients were scheduled for CAT scans. All of the CAT scans were performed with a Hitachi W950SR scanner (Hitachi, To-

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kyo, Japan) in a standardized fashion with the same technician for each subject. Axial images taken at 3-mm intervals were obtained from the distal tibial diaphysis to the inferior aspect of the calcaneus with hips and knees extended and both feet resting against a footplate, as described by Martinez et al.[13] and Seltzer et al.[19] A footrest was used to align the ankle joint in a neutral position.

The control group consisted of 101 healthy active volunteers (58 women and 43 men) with an average age of 29 ± 7 years with no known ankle trauma. Control subjects were recruited from the general population via a poster. All study subjects signed an informed consent form approved by the hospital's ethics committee before CAT scanning was conducted. Patients with general ligamentous laxity, progressive neurologic disorder, a varus heel, or a varus plafond were excluded from the study.

The CAT scan was performed to compare the axial malleolar index in patients with ankle sprain with those in the normal adult population. The axial malleolar index (transverse plane of the talus), which was first described by Scranton and associates,[18] was calculated in the following manner (Figs. 1 and 2): the plane of the articular surface of the talus was determined, and a line (A) was drawn that bisected this axis. A second line (B) was drawn, running perpendicular to the talar axis from the anterior border of the medial malleolus laterally. A third line (X) was drawn from the intersection of A and B running to the anterior border of the fibula. The angle between B and X represented the malleolar index. A positive number for the malleolar index meant that the lateral malleolus was posterior to the plane of the medial malleolus (Fig. 1). A negative number meant that the lateral malleolus was actually anterior to the plane of the medial malleolus. An independent observer measured all malleolar index values on the CAT scans. As a test of reliability, a random sample of 30 scans was measured in a blinded manner by two of the authors (OTE and MK). Interobserver reliability for measurement of the malleolar index was 94%.

All values were reported as means and standard deviations. The comparison of both groups was performed with use of a *t*-test and a chi-square test. Pearson's product-moment correlation coefficient was used to determine the correlation between the malleolar index values and frequencies of sprains. Significance was set at $P = 0.05$.

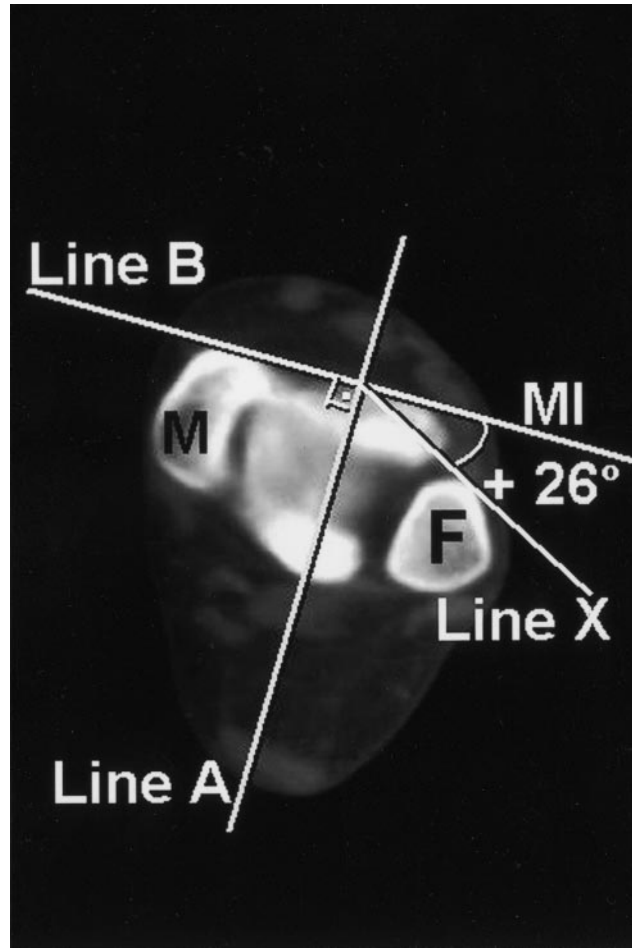

Figure 1. Computed axial tomographic illustration of the left ankle of a patient with a malleolar index of +26° (posteriorly positioned fibula). MI, malleolar index; M, medial malleolus; F, fibula.

RESULTS

Nineteen of the patients had experienced a first ankle sprain; 31, a second sprain; and 11, three or more sprains of the same ankle. There were 45 (74%) grade 2, 10 (16%) grade 3, and 6 (10%) grade 1 injuries, according to the classification of Trevino et al.[25]

The average malleolar index of the patients was +11.5°, with a standard deviation of 7°. Malleolar relationships varied from −6° to +39°, a range of 45°. The average malleolar index in the control group was +5.85° and varied from −8° to +16° (SD, +4.9°). The 95% confidence interval for the mean malleolar index of both groups was 3.61° to 7.68°.

There was a statistically significant difference in the malleolar index values between the patient and control groups ($P = 0.0001$). There was statistically poor correlation between the number of sprains and malleolar index values ($P = 0.82$; $r = -0.029$). No correlation was evident between age, sex, or side in either group ($P = 0.333$).

DISCUSSION

Ankle sprain is a very common injury, and its causes or predisposing factors have received much attention among researchers.[2,3,8,9,11,16,18,22,23,26] The intrinsic factors of proprioceptive deficiency and peroneal muscular weakness have been shown to contribute to recurrent sprains. It was hypothesized that proprioceptive deficits are caused by scarring of the soft tissues about the ankle after trauma, which damages the function of afferent fibers within the joint. This impairment may lead to decreased motor control of the ankle and may cause instability.[5] This hypothesis may explain why a positive history of an inversion ankle sprain is considered a risk factor for subse-

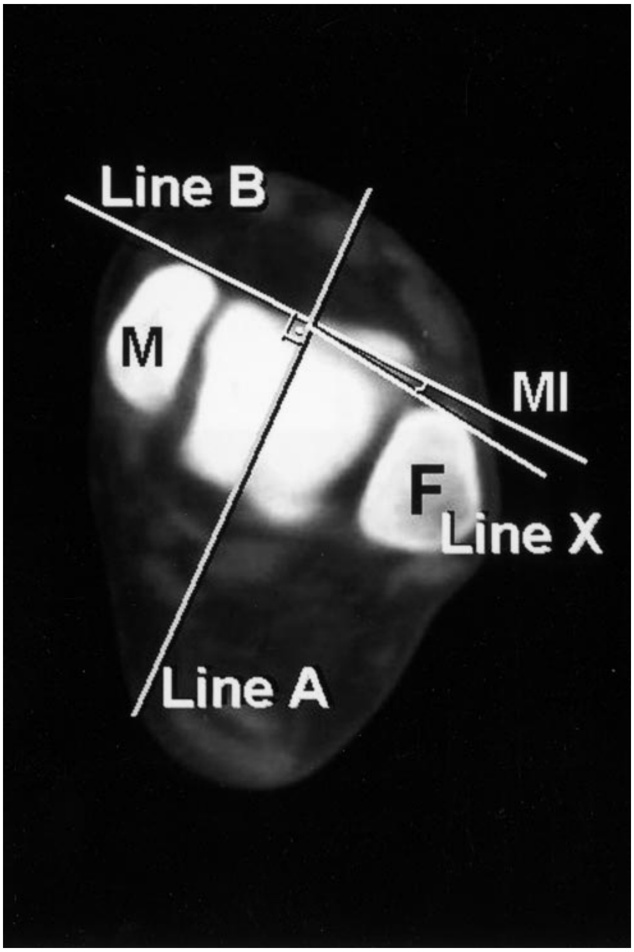

Figure 2. Computed axial tomographic illustration of the left ankle of a normal subject with a lateral malleolar border that was almost at the same level of the medial malleolus (malleolar index, +3°), relative to the transverse plane of the talus. MI, malleolar index; M, medial malleolus; F, fibula.

quent ankle injury.[6] Because the peroneal muscles act as the primary dynamic muscular stabilizers of the ankle joint complex, weakness of these muscles also may predispose people to ankle sprains.[9,17]

Baumhauer et al.[2] examined the intrinsic risk factors for inversion ankle sprains in a specified athletic population. They investigated factors that included generalized joint laxity, anatomic foot and ankle alignment, ankle ligament instability, and isokinetic strength. They found that only patients with ankle inversion and dorsiflexion weakness had a higher incidence of inversion ankle injury.

There is little evidence to support the claim that the presence of generalized joint laxity may predispose an athlete to ankle sprain. Most of the studies of joint laxity contributing to injury are limited to the knee joint.[4,15] Soderman et al.[22] investigated possible risk factors in female soccer players and found that generalized joint laxity, a low postural sway, a lower hamstring-to-quadriceps ratio during concentric action, and a higher exposure to soccer were related to a higher risk of traumatic leg injuries, including ankle sprains.

Although many studies have confirmed the increased incidence of ACL injuries among female athletes,[27] this correlation has not been found for ankle sprains. Lindenfeld et al.[10] found that male soccer players experienced a significantly higher number of ankle ligament injuries than did female players. Bahr et al.[1] and Messina et al.[14] could not find significant differences in the incidence of ankle sprains among male and female volleyball and basketball players.

The relationship between anatomic variations of the ankle and lateral instability has been recognized for many years. Bremer[3] first reported that varus position of the ankle during plantar flexion was a possible cause of lateral ankle instability. Sugimoto et al.[23] supported Bremer's findings and mentioned that a varus hindfoot or a varus tibial plafond may predispose people to lateral ankle instability.

The varus heel of a cavus foot has been cited as a predisposing factor in ankle sprain.[8] Colville[5] recommended that an osteotomy should be performed in patients who are undergoing ligament repair or reconstruction to correct the calcaneal varus. Conversely, these results were not confirmed by Soderman et al.[22] or by Baumhauer et al.[2] The measurements of anatomic foot alignment obtained in these studies were not found to be significantly different between uninjured and injured groups or within subjects.

Scranton et al.[18] first mentioned that abnormal variations in the position of the fibula relative to the medial malleolus can cause lateral ankle instability. The normal ankle mortise is saddle-like and lateral, and medial malleoli are usually at the same level with reference to the tibial plafond. This saddle-shaped mortise has optimal structural stability. Scranton[17] also hypothesized that a posteriorly positioned fibula opens the mortise, making the ankle more vulnerable to sprains. His hypothesis was based on a study in which the authors reviewed the CAT scan results of 100 consecutive patients who were seen for a variety of diagnoses, such as ankle sprain, avulsion fracture, or loose bodies.[18] In that study, the average malleolar index was found to be 9.3°, with a standard deviation of 6.5°. Although their study did not include a control group, they considered the malleolar index to be abnormal if the results were above 15°; this figure was obtained by summing the average malleolar index and the standard deviation. Scranton et al.[18] found that 65% of the patients with a malleolar index of 15° or more had a history of ankle sprain. Determination of the normal adult variation in the malleolar index was difficult in their study because of the absence of a control group. We found that the mean malleolar index plus the standard deviation in our control group was 10.75°, compared with 18.5° for our subjects, confirming the findings of Scranton et al.[18] However, the differences in the study designs make an exact comparison impossible.

It is possible to show the position of the fibula with a simple lateral radiograph, but standardization is difficult because a small amount of rotation can cause misinterpretations. Use of a CAT scan is optimal to verify the actual variation in the malleolar axial relationship.[13,18]

Once they have received a diagnosis of a posteriorly positioned fibula after an episode of ankle sprain, athletes may be advised to use external support during their sports activities. [20,24] Special emphasis on ankle strengthening and proprioception should be considered for these athletes.

There are many procedures described to stabilize the chronically unstable ankle. Excellent and good results of reconstructive procedures are reported in more than 90% of patients.[7,21] Significant reinjuries are often postulated as the cause of residual instability,[7] but we believe that a posteriorly positioned fibula may play a role in these circumstances. We suggest investigating the position of the fibula in revision cases.

The results of this study show that a posteriorly positioned fibula is associated with ankle sprains. However, there is a statistically poor correlation between the number of sprains and the malleolar index, so we could not show a relationship between recurrence of the injury and a higher malleolar index. Our study used a case control design; therefore, our results should be verified with population-based studies before specific treatment protocols can be established. It is important to remember also that anatomic factors make no contribution to injury until the body is in movement. Therefore, the effects of anatomic variations on the risk of ankle sprains have to be evaluated dynamically during athletic tasks.[27] We may then be better able to analyze the unclear and conflicting results of studies in which risk factors of ankle sprains have been outlined. It appears that many risk factors may contribute to ankle sprains at the same time. We believe that a posteriorly positioned fibula is one of the factors that may predispose people to ankle sprain. However, further studies are needed to address the interaction effects of all these factors on the incidence of ankle sprains.

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