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Radiographic Assessment of Fibular Length Variance: The Case for "Fibula Minus"

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ABSTRACT

Given the high prevalence of ankle fractures and morbidity of malalignment after fixation, an appropriate anatomic relationship between the distal fibula and adjacent tibia and talus is important. The tip of the lateral malleolus of the fibula has often been described to be at the level of the lateral talar process. However, no studies to date have examined the relationship of the distal fibular tip to the lateral process of the talus. We assessed 66 weightbearing mortise radiographs for variability of the distal fibular tip in relation to the lateral process of the talus. The subjects were all skeletally mature, with a mean age of 45.3 ± 14.6 years. We used a paired *t* test with a null hypothesis that the true mean difference in the distance from the distal fibula to the lateral process was equal to 0. The mean distance of the distal tip of the fibula was 0.257 ± 0.127 cm proximal to the tip of the lateral process of the talus. The 95% confidence interval was 0.226 to 0.288. Of the 66 subjects, 65 had the distal tip of the fibula proximal to the lateral process of the talus, corresponding to a negative fibular variance. In the remaining subject, the distal tip of the fibula was at the same level of the tip as the lateral process of the talus. The distal tip of the fibula is most commonly not at the level of the talus lateral process, as often described in published reports. Instead, it has a variance analogous to the relationship between the lengths of the ulna compared with the radius. The distal tip of the fibula in our study was more often proximal to the tip of the lateral process of the talus and can be described as a negative fibular variance, or "fibula minus."

Fractures of the foot and ankle are common injuries. Approximately 2% of the general population will sustain an ankle fracture during their lifetime (1). Many can be successfully treated nonoperatively. However, for those injuries that require surgical intervention, restoration of the anatomy is the main principle (2).

Biomechanical studies have demonstrated significant alterations in stability and joint reactive forces with fibular displacement (3–5). In a cadaveric study assessing the various effects of combinations of shortening and external rotation of the fibula on joint contact area, 30° of external rotation combined with 2 mm of shortening resulted in a >30% decrease in tibiotalar contact (6). After division of the deltoid ligament, the tibiotalar contact decreased by one half. In other studies, as little as 1 mm of lateral talar displacement decreased the contact area of the ankle joint by <40% (3,6). For the restoration of normal ankle mechanics, anatomic restoration of both fibular length and rotation is essential (6).

The key treatment of displaced ankle fractures is anatomic reduction with open reduction and internal fixation, until bony union has been achieved (7,8). Yablon et al (5) found the key to obtaining anatomic reduction of the mortise is to first perform an adequate reduction of the lateral malleolus. In 1 study of bimalleolar fracture cadavers, the talus could be anatomically repositioned only when the lateral malleolus was accurately reduced. Yablon et al (5) also noted that the displacement of the talus successively followed displacement of the lateral malleolus and that residual displacement of the fracture led to a poor result.

Continued lateral talar subluxation, often due to a shortened fibula, is usually indicated by a widened medial clear space. The most common mistake when attempting to reduce the size of the medial clear space is to use syndesmotic screws or bone clamps to "squeeze" the tibia and fibula together. However, with this maneuver, a widened medial clear space will persist because the mortise will not have been reduced. Instead, a distraction technique is needed to restore the anatomic length

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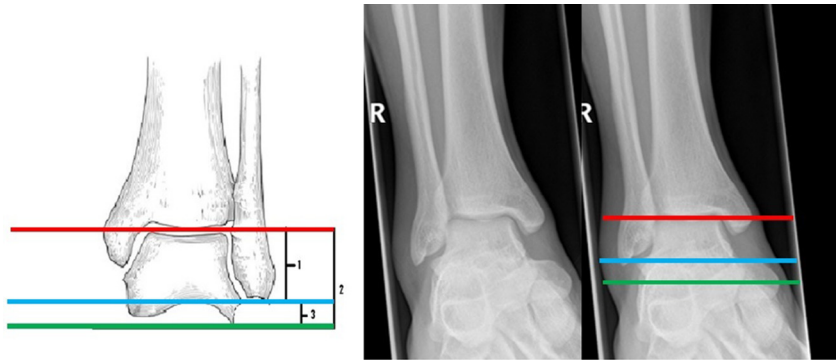

Fig. 1. Method to determine fibular variance. *Distance 1* is the distance between a line drawn parallel to the articular surface of the distal tibia and a line drawn parallel to the distal tip of the fibular. *Distance 2* is the distance between a line drawn parallel to the articular surface of the distal tibia and a line drawn parallel to the tip of the lateral process of the talus. *Distance 3* (distance 1 minus distance 2) is the distance between the distal tip of the fibula and the tip of the lateral process of the talus, which is neutral if this distance is 0.

of the fibula to achieve reduction of the mortise indicated by reduction of the medial clear space (2).

Despite considerable research in defining the length of the fibula, no studies reported to date have examined the relationship of the distal fibular tip to the lateral process of the talus. The principal aim of the present study was to assess the potential variability of 3 distances that define the anatomic location of the distal fibular tip. At the wrist, the ulnar variance relative to the length of the radius has been described. We hypothesized that a measurable distance exists between the distal fibula and lateral talar process. To quantitatively define this distance, we undertook a retrospective cohort study to determine the mean average location of the distal fibula tip compared with the lateral talar process using radiographic analysis.

Materials and Methods

We determined the distance between the distal fibula and lateral talar process by calculating the difference between the distances that define the anatomic location of the distal fibular tip. The 2 distances measured were the distance between a line drawn parallel to the articular surface of the distal tibia and a line drawn parallel to the distal tip of the fibula; and the distance between a line drawn parallel to the articular surface of the distal tibia and a line drawn parallel to the tip of the lateral process of the talus. The calculated distance was between a line drawn parallel to the tip of the lateral process of the talus and a line drawn parallel to the distal tip of the fibula (Fig. 1).

We conducted an observational study measuring the distances as defined using 66 randomly selected weightbearing mortise view radiographs of adults (aged ≥18 years). Radiographs were selected by International Classification of Diseases, revision 9, coding staff from June 2009 to January 2011 in a consecutive series. Measurements were taken using the Picture Archiving and Communication System (Siemens Medical Solutions USA, Inc., Malvern, PA) software measurement tools by the principle author, a foot and ankle fellowship-trained surgeon (V.K.P.) and his partner. None of the radiographs used in the present study had pathologic features related to the ankle mortise. Only skeletally mature subjects with no previous osteoarticular surgery of the ankle and no history of traumatic injury or congenital deformity to the lower leg and ankle were included. To analyze the data collected, we used a paired *t* test with a null hypothesis that the true mean distance from the distal fibula to the lateral process would be equal to 0.

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Results

The mean average age of the subjects was 45.3 ± 14.6 years. Of the 66 subjects, 23 were male (34.8%) and 38 were female (57.6%); the sex of 5 subjects (7.6%) was not recorded. The mean distance from the distal tibia to the distal fibular tip was 2.14 ± 0.321 cm. The 95% confidence interval (CI) was 2.06 to 2.22 cm. The mean distance from the distal tibia to the lateral process of the talus was 2.40 ± 0.326 cm. The 95% CI was 2.32 to 2.48 cm. The mean distance of the distal tip

Table
Summary of the results (N = 66 subjects)

Measure	Distance (cm)
Distal tibia to distal fibular tip	
Mean	2.14
Standard error	0.04
Median	2.16
Mode	2.38
Standard deviation	0.32
Sample variance	0.1
Range	1.75
Minimum	1.19
Maximum	2.94
Count	66
95% CI	0.08
Upper CI	2.22
Lower CI	2.06
Distal tibia to lateral process of talus	
Mean	2.4
Standard error	0.04
Median	2.43
Mode	2.22
Standard deviation	0.33
Sample variance	0.11
Range	1.75
Minimum	1.43
Maximum	3.18
Count	66
95% CI	0.08
Upper CI	2.48
Lower CI	2.32
Distal fibular tip to lateral process of talus	
Mean	0.26
Standard error	0.02
Median	0.24
Mode	0.24
Standard deviation	0.13
Sample variance	0.02
Range	0.55
Minimum	0
Maximum	0.55
Count	66
95% CI	0.03
Upper CI	0.29
Lower CI	0.23

In 65 of the 66 subjects, the distal tip of the fibula was proximal to the lateral process of the talus, corresponding to a negative fibular variance. In the remaining subject, the distal tip of the fibula was at the same level of the tip as the lateral process of the talus. No subjects in the present series had a positive fibular variance; the mean distance in females was 0.24 cm and in males was 0.28 cm, not a statistically significant difference. Abbreviation: CI, confidence interval.