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Narrowing the Normal Range for Lateral Ankle Ligament Stability with Stress Radiography

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A R T I C L E I N F O

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A B S T R A C T

Stress radiographs are commonly performed to evaluate lateral ankle ligament stability; however, little agreement exists on the physiologic limits obtained from the anterior drawer and talar tilt stress tests. Published studies have reported the normal range for the anterior drawer test to be 3 to 10 mm and the normal range for the talar tilt test to be 0° to 23° for the uninjured ankle, leading to inconsistent interpretation. The primary objective of the present study was to narrow the threshold for the diagnosis of ankle ligament injury using stress radiographs by refining the values seen in the normal ankle. An improved understanding of normal ankle motion could allow for a more accurate determination of ligament injury using stress imaging. Conducted in a simplified, yet reproducible, manner, we hoped the present study would draw a parallel with generalized use in an office setting and would allow physicians the ability to more effectively diagnose ankle ligament injury. Bilateral radiographic images of anterior drawer and talar tilt stress tests were taken of 50 participants (100 ankles) with no history of ankle fracture or surgical intervention for ankle instability. Participants with a previous ankle sprain were later excluded from the result computations. Factors such as patient age and gender were evaluated. In the final analysis, 46 participants (76 ankles) were included, with a mean anterior drawer test result of 2.00 mm ± 1.71 mm and talar tilt test result of 3.39° ± 2.70° in the normal ankle. The results of the present study suggest that stress radiographs for lateral ankle stability can be performed in a simple and reliable manner. These results also support a much lower threshold for the diagnosis of lateral ankle injury than previously reported.

Ankle injuries are the most common musculoskeletal injury in sports (1), with lateral ankle sprains constituting about 85% of these injuries (2,3) and resulting in a predisposition to future injury. Three major ligament groups support the ankle joint, including the tibiofibular syndesmotic ligament, deltoid ligament, and lateral ligament complex. Of the lateral ligament complex, the anterior talofibular ligament (ATFL) and the calcaneofibular ligament (CFL) are the 2 most frequently injured. Lateral ankle ligament injuries are graded from 1 to 3 according to increasing ligament damage and morbidity. A grade 1 sprain has been defined as microscopic tears and stretching of the ATFL without frank ligament disruption. On examination, no mechanical instability will be found. A grade 2 sprain has been defined as a complete tear of the ATFL and a partial tear of the CFL. Mild instability will be noted on examination. A grade 3 sprain has been defined as a complete rupture of the ATFL and CFL, with moderate to severe laxity noted with the anterior drawer (AD) and talar tilt (TT) tests. However, swelling and muscle spasm can mask pathologic findings (4–6).

AD and TT stress radiographs are often used in the clinical setting to assess the integrity of the lateral ankle ligament complex after injury. Little agreement exists regarding the range of normal and abnormal values obtained using these tests. The normal range for AD has been reported to be 3 to 10 mm, and the values for TT have been reported to be 0° to 23° (7). This wide range of reported values has made the interpretation of results difficult. A number of variables can explain these wide ranges, including the technique used and the calculation of measurements. Controversy remains on whether the stress views should even be performed and whether they should be done manually or with a mechanical device, such as a Telos® (Telos® Medical Equipment, Fallston, MD). Using manual versus mechanical stress testing can result in significant differences in the amount and duration of force applied (8). Measurement variability can also result from the criteria used and intrinsic measurement error (9,10).

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The primary objective of the present study was to establish a more precise normal range of motion of the lateral ankle ligaments during stress fluoroscopy that could then be used in diagnosing and guiding the treatment of lateral ankle ligament injury. An improved awareness of normal ankle motion during stress imaging could indirectly improve our understanding of the expected radiographic results in ankle ligament injuries. It is important to realize that these tests cannot and do not accurately quantify the severity of the injury; however, proper evaluation by the physician can guide the appropriate course of treatment to prevent long-term complications (11–14). The secondary goal of the present study was to determine whether these tests can be conducted in a simplified, reproducible manner, without the use of a mechanical testing device that would correlate well with use in the office setting.

Participants and Methods

The DeKalb medical institutional review board approved the present study. Individuals who worked at DeKalb Medical in Decatur, Georgia, were verbally invited to participate in the present study. We enrolled 50 participants (100 ankles) for a period of 1 month, beginning May 6, 2011 and ending June 6, 2011. The participant selection criteria included adult males and females aged 18 to 70 years. The exclusion criteria included a history of an ankle sprain or fracture, previous surgical intervention for lateral ankle instability, and pregnancy. At the final analysis, 46 participants (76 ankles) were included.

After providing informed consent and completing a questionnaire (Fig. 1), each participant was seated in a chair with the portable fluoroscopic unit (Model 340; Fluoroscan Premier, Northbrook, IL) in front of the chair. A lead apron was worn by the participant and the examiner (L.D.) to minimize radiation exposure. Four radiographs were obtained: lateral views of both ankles during stress application for the AD test and anteroposterior views of both ankles during stress application for the TT test. The initial 10 participants underwent stress views (both AD and TT) using the Telos® stress device (Telos® Medical Equipment) and manual stress testing. The 2 methods of measurement did not differ significantly for the first 10 participants; hence, the study was completed using only the manual stress views for the last 40 participants. The Telos® device (Telos® Medical Equipment) was not used for the entire study, because these devices are not common in the office setting, and our study was intended to reach as broad an audience as possible.

The AD test was performed by the examiner placing 1 hand on the tibia above the ankle and the contralateral hand on the posterior aspect of the calcaneus. Posterior force was applied to the tibia and anterior force to the calcaneus. The foot was maintained perpendicular to the leg, with the knee flexed (10,32). The TT test was performed with 1 hand placed just proximal to the medial malleolus to stabilize the tibia. The contralateral hand was placed on the lateral aspect of the hindfoot, which was inverted while maximal manual stress was applied. The foot was maintained in a slightly plantar flexed position in reference to the leg (15,33). One examiner (L.D.) took all stress views to maximize the reproducibility and reliability.

The data collection included participant gender, age, questionnaire, ankle laterality, and printed radiographs of the stress tests for measurement of the AD and TT. The questionnaire (Fig. 1) included questions on the history of ankle pain with activity (never, occasionally, or often), history of ankle sprain (which ankle and when), and history of ankle fracture (which ankle and when). A history of ankle fracture automatically excluded the participants from the study, and any ankle with a previous sprain was excluded from the data calculations. After testing of all study participants, the anteroposterior and lateral radiographs were evaluated by 1 investigator (M.G.) as follows. Anterior talar displacement was obtained using the plafond to dome method (16). The posterior margin of the articular surface of the tibia was used as a fixed point of reference, and the distance between this point and the nearest point on the talar dome was measured in millimeters (Fig. 2*A* and *B*); therefore, the shortest distance between the posterior edge of the tibia and the talar dome was measured. The TT was determined by drawing a line across the articular surface of the tibia and talus and obtaining the degree of lateral opening angle formed by the 2 (Fig. 2*C* and *D*).

Participant Questionnaire

Please circle the appropriate answer.

Do you have ankle pain with activity?	Never	Occasionally	Often
Have you had an ankle sprain in the past?	Yes	No	
If yes, which ankle?	Left	Right	
How long ago?	< 1 yr	< 5 yrs	> 10 yrs
Have you had an ankle fracture in the past?	Yes	No	
If yes, which ankle?	Left	Right	
How long ago?	< 1 yr	< 5 yrs	> 10 yrs

Fig. 1. Sample of questionnaire that each participant completed.

We analyzed our data with attention to the type and distribution and have described our cohort of participants using descriptive statistical methods. We also used tests of the null hypothesis to compare the outcome measurements procured using manual stress testing versus mechanical testing with a specific device designed to stress the ankle. We used this information to decide whether the mechanical device would need to be used throughout the investigation. Statistical significance was defined at the 5% level ($p \leq .05$).

Results

At the initiation of the present study, a paired samples *t* test was conducted to compare the difference between manual stress testing and use of the Telos® device (Telos® Medical Equipment) for both AD and TT tests. We were interested in knowing whether a statistically significant difference would be present between the Telos® (Telos® Medical Equipment) and manual measurements of the AD and TT. The AD computations showed no significant difference between the scores using manual testing (mean 3.92 ± 079) and the Telos® stress device [mean 4.00 ± 1.13; t(11) −0.432; $p = .674$]. The TT computations also showed no significant difference between the scores using manual testing (mean 3.00 ± 3.22) and the Telos® stress device [mean 3.08 ± 3.20; t(11) = −1.00; $p = .339$]. Thus, the decision was made to proceed with the planned study, excluding the use of the Telos® stress device (Telos® Medical Equipment).

A total of 100 ankles were tested, both the right and left ankles in each of the 50 participants. However, 20 participants (40%; 24 ankles [24%]) reported a history of ankle sprain in 1 or both ankles. The pathologic side was excluded from the result computations, leaving 76 ankles in 46 participants in the final analyses, including 30 bilateral ankle (65%) and 16 unilateral ankle (35%) participants. Four of the participants had bilateral injured ankles and were completely excluded from the present study. Of the 46 participants, 24 (52%) were male (38 ankles) and 22 (48%) were female (38 ankles). The mean age for the group was 41 years; the mean age of the female participants was 38.6 years and that of male participants was 45.3 years.

The mean AD was 2.00 ± 1.71 mm (range 0 to 5, mode 0). The mean TT angle was 3.39° ± 2.70° (range 0° to 10°, mode 0°). The mean AD and TT values were compared by gender. The mean AD was 1.87 mm for both males and females. The mean TT was 2.68° for the males and 4.11° for the females. A comparison was also done for the contralateral AD and TT mean values. The mean AD was 1.92 mm for the right and 2.03 for the left ankle. The mean TT was 3.18° for the right and 3.45° for the left ankle. The Mann-Whitney *U* test was also calculated for these groups and was 744.5, 901.5, 742.5, and 741.5 for the AD male to female, TT male to female, AD right to left, and TT right to left comparisons, respectively (Table). The values for the 2 samples compared in each group were not significantly different ($p \geq .05$, 2-tailed test) in each of the 4 groups.

Discussion

When discussing lateral ankle ligament injuries, the general agreement has been that untreated or inadequately treated injuries can result in serious sequelae, including continued pain, swelling, and instability (17–19). Therefore, narrow and accurate ranges for the AD and TT measurements obtained using plain film stress radiography could play an important role in the diagnostic analysis of ankle injuries. Our results suggest that injuries to the lateral ankle ligaments