# COMPARISON OF TWO MANUAL TESTS FOR ANKLE LAXITY DUE TO RUPTURE OF THE LATERAL ANKLE LIGAMENTS

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## ABSTRACT

**Background: Assessment of ankle laxity can be both subjective and difficult, especially in less-experienced hands. The commonly-practiced anterior drawer test can mislead practitioners in the diagnosis of ankle instability due to subtalar joint motion. A manual stress test, focusing on tibiotalar translation, may be required.**

**Objective: To evaluate the validity, reliability, and diagnostic accuracy of the modified manual stress test - the anterolateral drawer test (ALDT) - compared with the original anterior drawer test (ADT) in two groups of examiners with different levels of experience.**

**Methods: A cadaveric study was performed at University Research Laboratory. Nine below-the-knee specimens were randomized into three groups to simulate different degrees of lateral ligament injury. Two groups of examiners (Group A was four athletic training students; Group O was four senior orthopaedic trainees) performed ADT and ALDT while direct anatomical measurement (DAM) of tibiotalar translation was used as a reference under controlled load (Telos device). Ankle translation from DAM, ADT, and ALDT was recorded in millimeters. Measurements were compared using a paired t-test. Pearson correlation was used to determine linear relationship between groups. Inter- and intra-rater reliability was identified using ICC (intraclass correlation coefficient). The diagnostic threshold was determined by a receiver operating characteristic curve.**

**Results: Both groups of examiners demonstrated excellent intra-observer reliability (0.94 for ADT and 0.80 for ALDT) and fair-to-good inter-observer reliability (0.52 for ADT and ALDT). There was no difference in the mean of measurement between group A and group O except for the ALDT on intact specimens (*P* = 0.01) and the ADT on the ATFL+CFL cut specimens (*P* = 0.02). Correlation with the DAM was superior in the ALDT (r = 0.73) compared to the ADT (r = 0.57). When using 4 mm or more as a diagnostic threshold, sensitivity and specificity (respectively) were found to be 100% and 66.67% for the ADT and 100% and 66.67% for the ALDT.**

**Conclusion: For diagnosis of ankle ligament injuries, this cadaveric study demonstrated high sensitivity, reliability and correlation with the gold standard using ADLT, regardless of the examiner's experience.**


**Keywords: Ankle instability, anterior drawer test, anterolateral drawer test, ankle ligament, ankle laxity.**

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## INTRODUCTION

Chronic ankle joint instability can develop in 19% to 72% of patients following lateral ankle sprains.[1-3] The common presenting complaints are pain, fear of giving way, actual instability symptoms, and/or swelling that interferes with daily living and/or sport activities.[2] After an acute injury, adequate diagnosis and treatment are important to expedite recovery and to prevent chronic ankle joint instability. In addition, it is important to assess the degree of ankle laxity in order to determine the presence of mechanical instability which may not improve following rehabilitation or the use of orthotics.[4,5] On a subacute or delayed basis, laxity of the ankle joint is also a key factor in guiding further treatments and as an indication for surgical repair or reconstruction of the lateral ankle ligaments.

Instability of the ankle joint after a sprain can be evaluated by manual examination or instrumented stress testing, with or without radiographic or ultrasonographic assistance. Stress radiographs[6,7] have been used for this purpose; however, these have not been very helpful in deciding treatment because of their lack of reliability.[8] While the use of ultrasonography has shown promising results, the technique is operator-dependent and may not be widely available.[9-14] Different ankle testers have been designed to measure displacement between the calcaneus and the tibia under controlled loading without radiography. However, the validity of the testers has been questioned due to possible false laxity through the subtalar joint.[15, 16] In a clinical setting, the anterior drawer test (ADT) is generally used as a manual test to evaluate ankle instability.[17, 18] The test is usually performed with one hand stabilizing the distal tibia and the other hand pulling the foot anteriorly without any attempt to isolate the displacement from only the tibiotalar joint.[19] Determination of instability by this technique can be subjective, has a lack of sensitivity, and is difficult, especially in less-experienced hands.[20-29] In addition, the test can only evaluate the total combined laxity across both tibiotalar and subtalar joints. Due to the need for a better test for clinical use, the anterolateral drawer test (ALDT) was developed and has been routinely used by the senior author (PP) since 2006. This technique is a modification of one described by Mann et al[30, 31], regarding specific positioning of the hands and fingers to allow appreciation of isolated laxity of the lateral ankle joint by direct palpation of the tip of the fibula and the lateral talus as anterolateral rotatory subluxation occurs.

In a previous study, we found that the ALDT demonstrated high sensitivity and accuracy in determining lateral ankle laxity in cadaver specimens.[31] That study also demonstrated the ALDT had superior linear correlation with the Telos stress device when compare to the ADT. The promising initial results of this technique warranted further validation in larger groups of examiners with differing levels of experience.

In this present study, we evaluated the reproducibility and sensitivity of two ankle laxity tests (ADT and ALDT) for lateral ankle ligament instability as performed by a group of senior orthopaedic trainees and by a group of athletic training students. We hypothesized that the ALDT would show higher correlation with directly measured talar displacement and provide higher accuracy for the diagnosis of lateral ankle ligament rupture than the ADT for both groups of examiners.

## MATERIALS AND METHODS

Nine fresh-frozen human ankle specimens (four pairs and a single ankle) were obtained from two male and three female donors with a mean age of 55 years (range, 48 to 70 years). The number of specimens was determined by the availability of cadavers. Each specimen was thawed at room temperature for 24 hours before testing. Specimens with limited range of motion or any evidence of prior surgery were excluded. Three groups, each containing three specimens, were blindly assigned: intact ligaments, anterior talofibular ligament (ATFL) cut, and anterior talofibular ligament and calcaneofibular ligament (ATFL+CFL) cut. Each specimen had the same lateral curvilinear incision, regardless of the ligament transection. Bone pins were placed on the center of the fibular and talar attachments of the ATFL. The distance between the pins was measured using a vernier caliper with 0.01 mm precision as a baseline distance. The distance between the same pins was again measured while the ankle was under anteriorly directed force of 15 kilopascals (143 Newton) on the Telos stress device (Austin & Associates, Inc., Telos Medical, MD, USA) with the same position of the ankle, 20 degrees of plantar flexion.[26, 32] This difference between the measured distance and the baseline distance was recorded as a direct anatomic measurement (DAM). The DAM was considered the gold standard for the ankle laxity tests. The skin was meticulously closed. Two investigators (TV and PP) who were not involved in the manual testing prepared all specimens.

Two groups of examiners with differing experience levels were selected. Group A included four athletic training students with an average of 2.25 years clinical experience. Group O included four senior orthopaedic trainees (three fourth-year orthopaedic residents and one foot-and-ankle fellow) with an average of 4.5 years clinical experience. Each group applied both ankle laxity tests to all specimens. All examiners were instructed in ADT and ALDT using a video demonstration provided by a fellowship-trained foot-and-ankle surgeon (PP). All were allowed to practice with a plastic ankle model for up to one hour before actual specimen testing. The ADT was performed with one hand stabilizing the leg just above the ankle joint; the heel was then grasped from behind with the opposite hand, and an anterior force was used in an effort to produce forward translation[33] (Figure 1B). The ALDT was performed with one hand stabilizing the leg just above the ankle joint. The index and middle fingers of the opposite hand were then pressed firmly against the posterior aspect of the heel to provide a gentle anteriorly directed force. The palm supported the sole of foot to stabilize the ankle in slight plantar flexion. The thumb was placed along the lateral aspect of the talar dome and the anterior aspect of the lateral malleolus. Anterior translation was applied at the posterior aspect of the heel while the foot was allowed to rotate internally. Any step-off was palpable by the thumb[31] (Figure 1A).

Each of the nine specimens was randomly arranged at testing stations with the tibia secured in a vertical

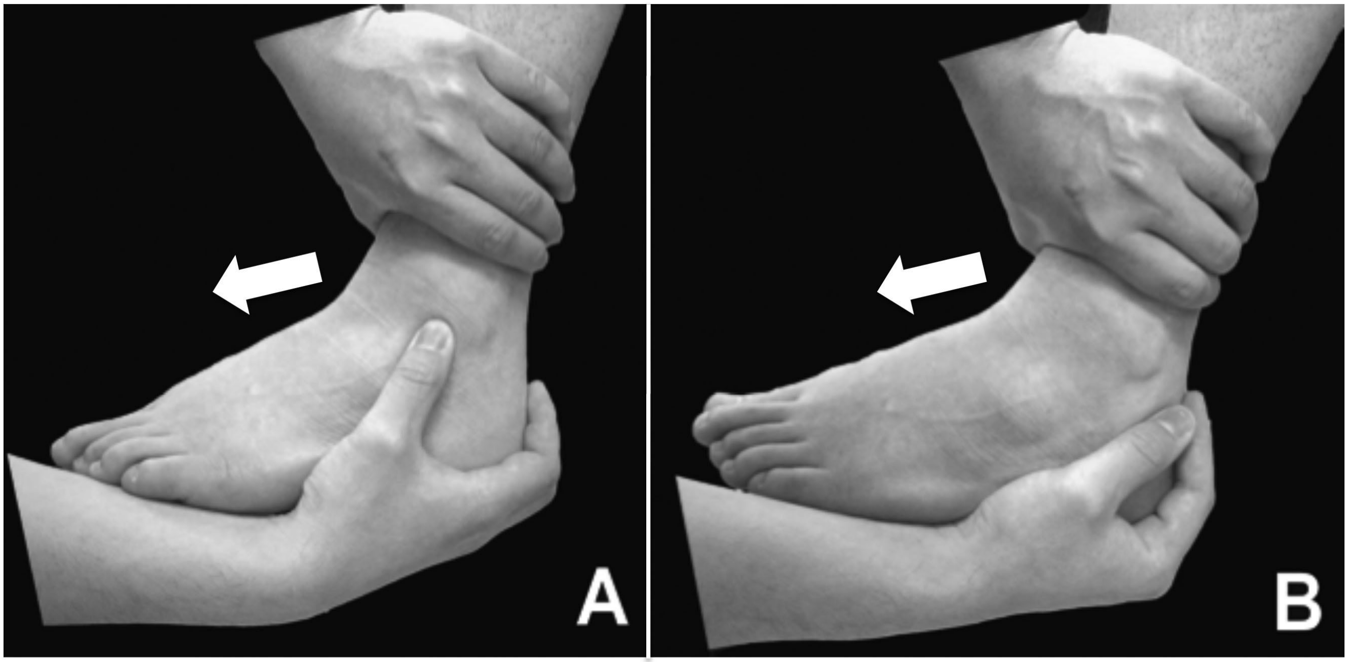


**Figure 1. Ankle laxity examinations are demonstrated on a left ankle; the anterolateral drawer test (A) and the anterior drawer test (B). The arrows indicate translation direction.**

**TABLE 1. The mean and standard deviation (mm) from different measurement techniques for all specimens categorized by the degree of ligamentous destabilization**

| | Intact | ATFL cut | ATFL+CFL cut |
|---|---|---|---|
| DAM | 0.4 ± 0.1 | 5.7 ± 1.7 | 9.4 ± 2.7 |
| ADT (O+A) | 3.9 ± 1.6 | 5.4 ± 1.7 | 5.3 ± 2.1 |
| O | 3.2 ± 1.4 | 6.5 ± 1.5 | 6.8 ± 1.2 |
| A | 4.5 ± 1.6 | 4.3 ± 1.1 | 3.8 ± 1.6 |
| ALDT (O+A) | 3.4 ± 0.7 | 5.2 ± 1.7 | 5.8 ± 2.0 |
| O | 2.8 ± 0.5 | 5.0 ± 1.8 | 6.1 ± 1.5 |
| A | 4.0 ± 0.4 | 5.5 ± 1.7 | 5.4 ± 2.6 |

"O+A" = data from all examiners
"O" = data from group O (orthopaedic trainees)
"A" = data from group A (athletic training students)
"DAM" = direct anatomical measurement

position while the foot and ankle were free of any constraint. The manual tests were performed twice on each specimen on separate occasions, using different specimen arrangements. All specimens were randomly placed using a random-number table. Without the use of a measuring device, the displacement of the talus was manually appreciated by each examiner from each test session and was recorded in millimeters.

The laxity data between the two groups of examiners were compared using a paired t-test. Pearson's correlation coefficient was used to determine the linear relationship between the DAM and the two laxity tests.[34] The correlation coefficients (r) were interpreted as weak (0.1-0.29), moderate (0.3-0.49), and strong (0.5-1.0).[35] Inter-observer and intra-observer reliabilities of the examiners were identified using ICC (intraclass correlation coefficient).[36] ICCs were interpreted to be poor-fair at ICC £ 0.4, fair-good at 0.4 < ICC < 0.75, and excellent at ICC ³ 0.75.[37] A post hoc analysis with a receiver operating characteristic (ROC) curve was used to determine a proper diagnostic threshold. The sensitivity and specificity of each laxity test was evaluated. All tests were performed with use of the SAS procedure (SAS 9.1.3; SAS Institute, Cary, NC) and using a significance level of alpha set at 0.05.

## RESULTS

The mean and standard deviation of the joint translation from different measurement techniques for all specimens, categorized by the degree of ligamentous destabilization, are shown in Table 1. The results from the ALDT showed significant differences in average measurements between group A and group O in specimens with the ligament intact (p=0.0083), and no significant difference in both the specimens with ATFL cut, or those with ATFL+CFL cut (p=0.6776 and p=0.6363, respectively, Figure 2A). However, for the ADT, the average measurement was statistically significantly different between group A and group O in the specimens

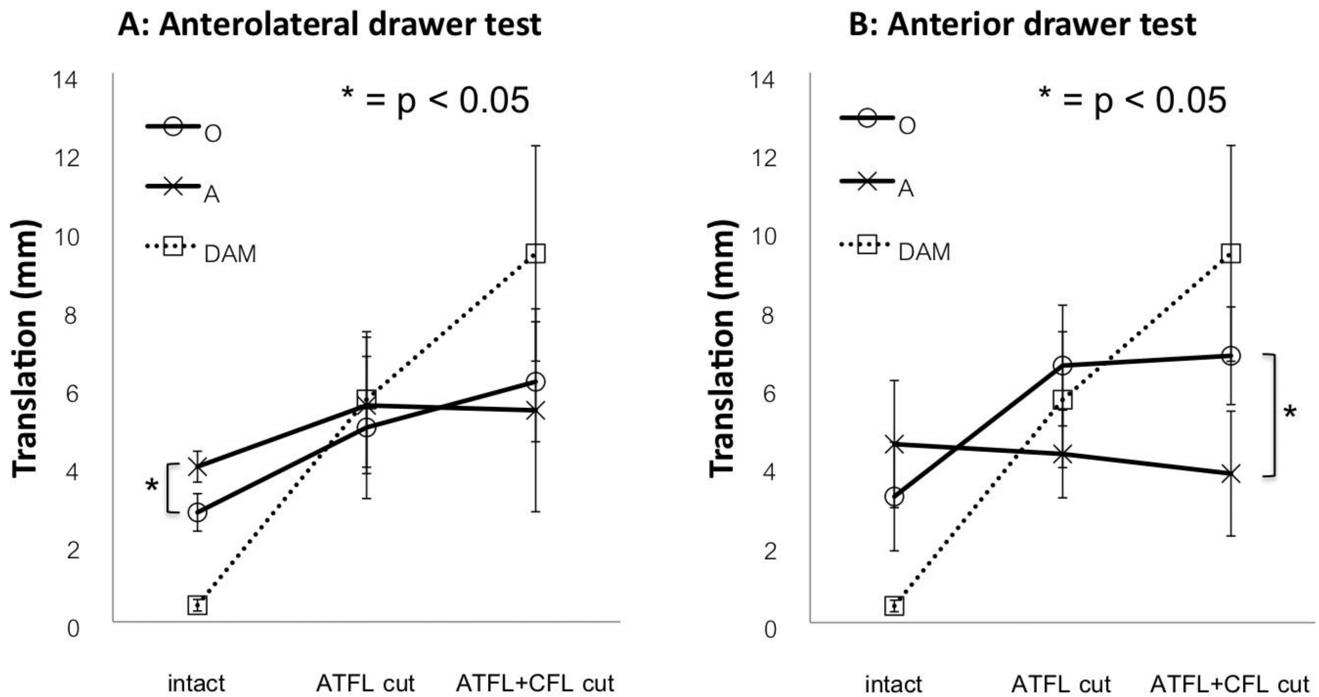


**Figure 2. The charts show the average degree of displacement from the anterolateral drawer test (ALDT, graph A) and anterior drawer test (ADT, graph B) in group O, orthopaedic trainees (O) and group A, athletic training students (A). The DAM (direct anatomical measurement) is shown in each graph as a control. The dispersion bars indicate standard deviations.**

with ATFL+CFL cut (p=0.0247). We found no significant differences between the two groups of examiners in the specimens with the intact ligament (p=0.2485) and ATFL cut (p=0.0585; Figure 2B).

Using Pearson's correlation coefficient to analyze a linear relationship between the DAM and ankle laxity tests, we found that the correlation between ALDT and DAM (r=0.7656, strong) was comparable to that between ADT and DAM (r=0.7621, strong) in group O (Figure 3). However, these two r's were not significantly different. Meanwhile, in group A the correlation between ALDT and DAM (r=0.6129, strong) was much higher than the correlation between ADT and DAM (r=0.0208, weak). The two r's were significantly different (p=0.0442).[34] Moreover, to evaluate the overall effects, we averaged the ADT and ALDT values over the two groups. The correlation between averaged ALDT and DAM (r=0.7332, strong) was higher than that between the averaged ADT and DAM (r=0.5704, strong). All of the results showed that ALDT was consistently more accurate in the diagnosis of a lateral ankle ligament rupture than ADT, over different groups of practitioners.

Intra-observer reliabilities identified using ICC were 0.9443 (excellent) for the ADT and 0.8017 (excellent) for the ALDT. Moreover, inter-observer reliability values for the ADT were 0.5274 (fair-good), and 0.5230 (fair-good) for the ALDT.

The best cut points with highest sensitivity and specificity to identify ankle ligament ruptures for the ADT and the ALDT were 3.81 and 3.97 mm, respectively, in ROC curves. When using 4mm or more of the displacement value as a threshold to diagnose lateral ankle ligament rupture for both manual tests, the sensitivity and the specificity, respectively, were found to be 100% and 66.67% for the ALDT, and 100% and 66.67% for the ADT (Figure 4).

## DISCUSSION

The ALDT demonstrated its ability to diagnose lateral ankle laxity well in both groups of examiners, even with different experience levels. In the more experienced group of examiners, group O, we recorded a trend: Laxity values from both the ADT and the ALDT increased continuously with the severity of ankle ligament injuries (Figure 2). In addition, this strongly correlated with the gold standard DAM (Figure 3).[38] This suggested the possibility that both ankle laxity tests were clinically applicable for examiners with more experience. However, in the less-experienced group A, we noted a different trend: Only the ALDT was useful in differentiating ankles with lateral ligament injury from intact ankles. In addition, correlation with the gold standard was sig-

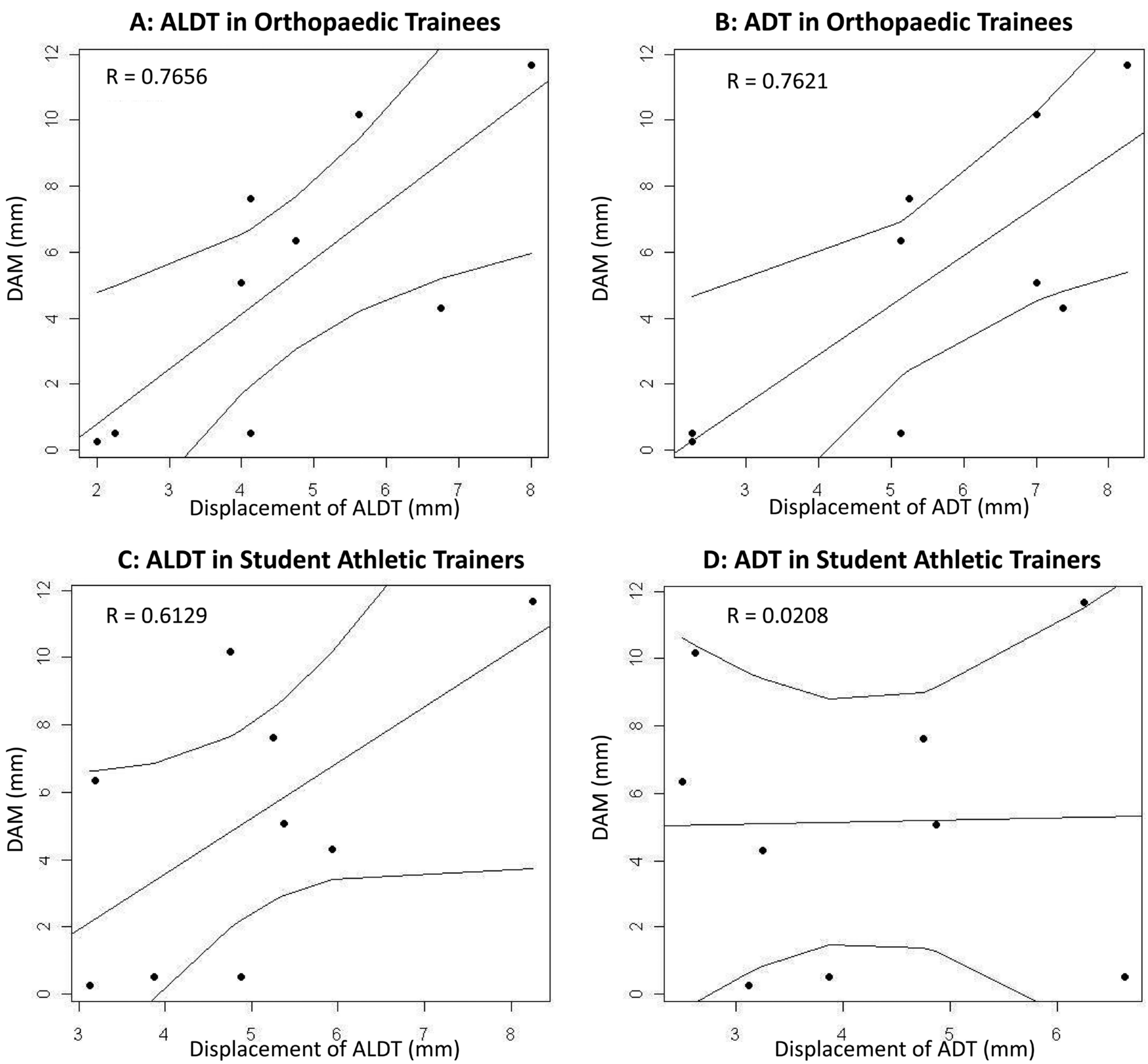


**Figure 3. Charts demonstrate Pearson's correlation between direct anatomical measurement and tests of ALDT and ADT, in orthopaedic trainees (A and B) and athletic training students (C and D). The correlation with the gold standard (DAM) was significantly higher in the ALDT as compared with the ADT**

nificantly higher in the ALDT when compared with the ADT (Figure 3). Regardless of examiner experience, the ALDT was found to be superior to the ADT in sensitivity without a compromise in specificity. The high sensitivity of this test even in non-specialist examiners is important in considering the role of this test as a screening tool for proper referral and treatment.[4, 5]

As in previous studies,[39-42] a laxity of 4 mm or more was found to be the best diagnostic threshold for lateral ankle ligament rupture. This was slightly higher than the value from our prior study (3 mm).[31] We believe that this effect occurred because of the difference in experience levels, and the number of examiners. In practice, the difference between the laxity of uninjured and injured limbs should be noted; however, a recommendation on the optimum number as a threshold cannot be made from our information.

Despite the fact that ankle sprains are well recognized as the most common sports injury, effective clinical evaluations of the degree of joint laxity are lacking.

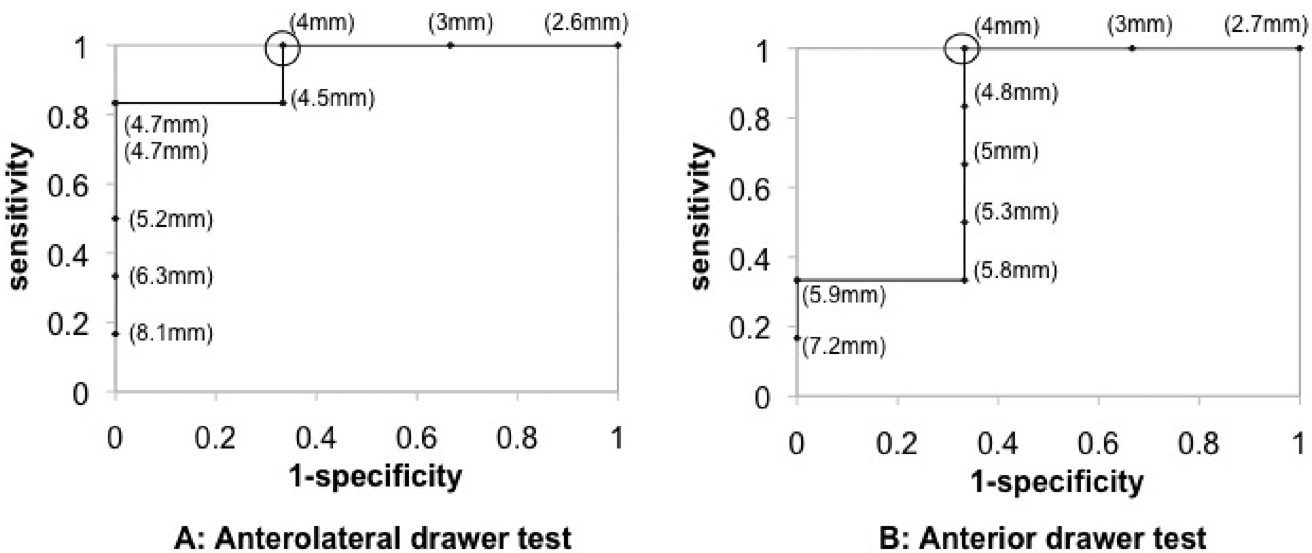


**Figure 4. ROC curves show the sensitivity and specificity in the diagnosis of lateral ankle ligament injury by the anterolateral drawer test (A) and anterior drawer test (B). The cut point of ≥4 mm is the best diagnostic threshold of lateral ankle ligament rupture with the highest sensitivity and specificity (circle).**

Multiple classification systems have been proposed for acute ankle sprains using the combination of pain, swelling, anatomical ligament disruption, manual stress testing and stress radiographs. While the degree of injury and instability have been overlooked, functional treatments are generally applied to most athletes who sustained an ankle sprain. This may, in part, explaine the relatively high incidence of subacute or chronic symptoms in athletes. In an epidemiologic study of 639 patients with ankle arthritis by Saltzman et al., 70% was post-traumatic in origin.[43] Single-incident and recurrent ankle sprains, interestingly, accounted for 28% of the entire post-traumatic group. The diagnosis of ankle instability in both acute and chronic settings may have been less than optimal.

Investigations into the evaluation of ankle instability have not been clinically successful despite extensive research. While some ankle stressors and ultrasound techniques may have shown some promising results, their use can be limited due to availability and their operator-dependent characteristics. It has been the senior author's impression that a slight modification of the manual examination technique significantly improves the accuracy of the anterior drawer test, as we report. The ALDT required simultaneous palpation of the step-off while applying translational force to the ankle. Both groups of examiners, with different backgrouns and experience levels, were able to be trained in this technique.

We recognize that the present study has several limitations. The training period prior to manual testing was relatively brief. This may have affected test performance for the less experienced examiners. However, both groups of examiners repeated their tests in a blinded fashion, and intra-observer and inter-observer reliabilities were excellent and moderate (ICC > 0.8 and ICC > 0.5, respectively). While we used millimeters for the threshold point of diagnosis, other commonly used instability grading systems e.g. mild/moderate/severe, absent/present, or same/different compared to the contralateral side, may yield different results in diagnostic accuracy. Unfortunately, there is no anatomically validated grading system for the anterior drawer test currently available. In addition, the degree of instability may not reflect the true degree of ligament disruption due to the inherent stiffness in cadaveric specimens. Also, a pain inhibition mechanism is absent in cadaveric studies, and associated soft tissue injuries such as capsular rupture and tendon damage are important factors which can complicate interpretation of the physical examination in a clinical setting. Finally, the small number of cadavers and evaluators might weaken the present results. Therefore, larger numbers of specimens and additional clinical studies are necessary to establish the efficacy of the ALDT.

For the diagnosis of ankle ligament injuries, this cadaveric study demonstrated the high sensitivity, reliability, and correlation with the gold standard of the ALDT, regardless of the examiners' experience. Further studies in clinical settings with larger sample sizes are warranted to establish the efficacy of the ALDT and its potential use as a diagnostic and screening tool.

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