Lateral Ankle Instability Increases Anterior Translation and Internal Rotation of the Talus during In Vivo Loading

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Introduction
Lateral ankle ligament sprains are one of the most common injuries in sports and recreation and are among the most frequently treated injuries in emergency departments. Although many patients have good clinical outcomes after conservative treatment, between 10 to 30% of patients with lateral ankle sprains are thought to experience chronic symptoms, including pain, instability, and osteoarthritis. Although previous studies have hypothesized that the abnormal kinematics caused by chronic lateral ankle instability contribute to the development of osteoarthritis, the effect of these injuries on the motion of the talocrural joint under in vivo weight-bearing conditions is not well understood. The objective of this study was to measure the motion of the talocrural joint in patients with chronic lateral ankle instability.

Based on the orientation of the anterior talofibular ligament (ATFL), we hypothesized that the anterior translation and internal rotation of the talus would increase in patients with chronic lateral ankle instability.

Materials and Methods
Seven subjects (4 males, 3 females, aged 19-57 years) participated in this study. Subjects recruited had unilateral ankle sprains which had been treated conservatively for at least 6 months and were diagnosed with chronic lateral ankle instability by an orthopaedic surgeon. Rupture of the ATFL was confirmed via MRI. Patients with osteochondral lesions were excluded from the study.

Subjects were imaged using a 3.0T magnet (Trio, Siemens, Germany) and an 8 channel receive-only foot and ankle coil (Invivo, Orlando FL). For each subject, each ankle was imaged separately using a 3D double-echo steady state sequence (DESS, Flip angle: 25°, TE: 6 msec, TR: 17 msec) with a 15cm by 15cm field of view. The resulting sagittal plane images had a resolution of 512 by 512 pixels and a slice thickness of 0.7 mm. In each image, the anatomy of the tibia and talus were outlined using solid modeling software. Each contour was then placed in the appropriate plane in space, and the curves were used to generate a 3D surface model of the tibiotalar joint.

Next, each patient was imaged using two fluoroscopes (Pulsar, Philips, The Netherlands) positioned orthogonally above a platform. The fluoroscopes recorded images simultaneously with a resolution of 1024 by 1024 pixels. Subjects stood on the platform and stepped onto a level surface within the beams of both fluoroscopes. Subjects stepped onto the platform while increasing the load from 0 to 100% of their body weight.

These images and the 3D model of the talocrural joint were used to reproduce the in vivo motion of the each subject’s ankles, using a manual model-based matching technique. From these models, the six degrees-of-freedom kinematics of the talocrural joint were recorded. The anteroposterior translation and internal rotation of the talus of each patient’s intact and injured ankle was compared using the Wilcoxon Signed Rank Test.

Results
In both the intact and injured ankle, the talus translated anteriorly with increasing load (Figure 1). However, the ATFL deficient ankle had increased anterior translation of the talus compared to the intact ankle at 100% body weight (p < 0.05). The talus in the unstable ankle was 0.9±0.5mm (mean ± standard deviation) anterior to the talus in the intact ankle.

In the intact ankle, there was a slight external rotation of the talus with increasing body weight (Figure 2). However, the ATFL deficient ankle rotated internally. For example, at 100% body weight, the talus in the deficient ankle was 6.7±2.8° internally rotated relative to the talus in the intact ankle (p < 0.05).

Discussion
This study demonstrated that injuries to ATFL are associated with increased anterior translation and internal rotation of the talus under in vivo weight-bearing conditions. The increase in anterior translation and internal rotation of the talus can be explained by the orientation of the ATFL fibers, which run anteromedially from the fibula to the talus (Figure 3). The altered joint motions of the talus might help to explain the development of osteoarthritis after chronic lateral ankle instability. Internal rotation of the talus relative to the tibia might shift contact toward the medial aspect of the talus (Figure 4), a region where cartilage degeneration is observed clinically. These data may be useful for evaluating and improving reconstruction techniques aimed at restoring normal ankle joint motion.

Figure 1. During in vivo loading, the talus in the ATFL deficient ankle translated anteriorly relative to the intact ankle. (* p < 0.05)

Figure 2. During in vivo loading, the talus in the ATFL deficient ankle rotated internally relative to the intact ankle. (* p < 0.05)

Figure 3. The ATFL fibers run anteromedially from the fibula to the talus, suggesting that the ATFL helps to restrain both the anterior translation and internal rotation of the talus. (A = anterior, P = posterior)

Figure 4. Increasing internal rotation of the talus could shift the contact towards the medial talus, a region where degeneration is observed in patients with chronic lateral ankle instability.

References