In Vivo Cartilage Contact Strains in Patients with Lateral Ankle Instability

Introduction

Lateral ankle sprains are a common problem, with the majority of sprains occurring in the anterior talofibular ligament (ATFL). Most sprains heal with conservative therapy, but 20-40% may progress to lateral ankle instability (LAI), with symptoms of chronic pain and instability. LAI is a clinical concern as it has been found to be a predisposing factor to the development of ankle osteoarthritis, especially on the anteromedial cartilage surfaces. Previous studies have hypothesized that altered tibiotalar kinematics resulting from lateral ligament laxity may predispose the joint to osteoarthritis, but the precise mechanisms are not well understood. The objective of this study was to evaluate in vivo cartilage contact strains of the tibiotalar joint in patients with LAI. Based on previous work demonstrating an increase in anterior translation and internal rotation of the talus in patients with LAI, we hypothesized that the peak cartilage strain would increase and shift anteromedially on the talus.

Materials and Methods

Five subjects (4 female, 1 male, aged 34-57) with unilateral ankle sprains who had failed conservative therapy for at least 6 months were included in this study. Subjects were diagnosed with lateral ankle instability by fellowship-trained foot and ankle surgeons, and ATFL damage was confirmed by MR imaging. Subjects with evidence of cartilage degeneration or arthritis were excluded. MR images were obtained using a 3.0T magnet (Trio, Siemens, Germany) and an 8-channel receive-only foot and ankle coil (InVivo, Orlando, FL). Both ankles were imaged using a 3D double-echo steady state sequence (DESS, flip angle 25 degrees, TE 5msec, TR 17msec) with a 15cm x 15cm field of view in the sagittal plane. Image resolution was 512 x 512 pixels with a slice thickness of 0.7mm. MR images were then imported into solid modeling software and positioned in a 3-D environment to reproduce the orthopedic orientation during testing. The 3-D ankle models created from the MR imaging were then imported into this environment and aligned simultaneously with the fluoroscopic images. From these models, the cartilage surfaces were aligned with the bones, and calculated cartilage strain across the tibiotalar joint using the overlap of the cartilage surfaces to approximate contact strains. Peak cartilage strain and the position of the peak strain between the intact and injured ankle of each patient was compared using the Wilcoxon Signed Rank Test.

Results

Ankles with chronic LAI demonstrated significantly increased peak strain at 50%, 75%, and 100% body weight when compared with the contralateral intact controls (Figures 1 and 2). At 100% body weight, peak strain was 32.8±6.40% on the injured side compared with 23.1±3.70% on the intact side (p<0.05). The position of peak strain on the talus in ATFL deficient shifted anteriorly at 50% -100%, and mediially at 100% body weight compared to intact ankles (Figures 3 and 4). For example, at 100% body weight, the location of peak strain demonstrated an increase in anterior translation of 15.8±7.70mm (p<0.05) and an increase in medial translation of 12.4±7.87mm (p<0.05).

Discussion

This study demonstrated that lateral ankle instability is associated with altered in vivo cartilage contact strain patterns. When compared to controls, chronic LAI resulted in increased peak cartilage strain and an anteromedial shift of maximum strain. The altered contact strains can be explained by the increased anterior translation and internal rotation observed after ATFL injury. The location of peak strain in our study corresponds to the region of clinically-observed cartilage degeneration in this population. Chronic LAI, therefore, may contribute to the development of tibiotalar cartilage degeneration due to altered cartilage contact strain patterns.

References:

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