INTRODUCTION

Injury of the interossseous talocalcaneal ligament (ITCL) of the calcaneus tarsi has been recognized as the most important cause of subtalar instability. However, clinical manifestations of ITCL failure remain mostly unclear, due to insufficient understanding of the role of the ligament. Lack of an accepted clinical test has detracted from the ability of clinicians to reliably make the diagnosis of ITCL failure. In this study, we investigated the functional role of the ITCL in stabilizing the subtalar joint, the effect of ITCL failure, and the appropriate direction for clinical examinations to detect ITCL failure. In particular, we examined the effect of ITCL sectioning on mechanical stability of the subtalar joint, using a standard ligament-sectioning paradigm.

METHODS

Five fresh frozen cadaver feet were subjected to both of two mechanical experiments: an axial distraction-compression test and a transverse multi-direction drawer test. In the axial test, cyclic compression-distraction forces were applied perpendicular to the sole plane. The transverse test consisted of six alternative-direction drawer tests. Cyclic negative-positive drawer forces were applied to the specimens along one of six axes parallel to the sole plane at 30° increments (Fig. 1). In each test, an MTS-810 testing machine was utilized to apply seven cycles of negative-to-positive and positive-to-negative drawer forces, up to 60N, with a loading frequency of 0.1Hz. Each specimen was first subjected to both axial and transverse tests in the intact condition. Both tests then were repeated after sectioning the ITCL.

The resulting load-displacement relationship was characterized by a sigmoid curve (Fig. 2). The nearly flat central region, termed neutral-zone laxity, was defined as the displacement between ±10N load. Neutral-zone laxity was measured for both positive-to-negative and negative-to-positive drawer forces, with the mean value regarded as the neutral-zone laxity parameter.

Beyond the neutral-zone region, the apparent stiffness of the joint increased monotonically with the magnitude of the applied force. To quantify the resistance of the subtalar joint against positive force, the data from 20 to 50 N were plotted semi-logarithmically [1], as the displacement [U] versus the applied load |F|; the data from ~20 to ~50 N were similarly plotted for the negative force. Because a linear relation was thereby consistently observed, the slope was defined as the flexibility parameter for each drawing direction.

The data were analyzed by a paired t-test for the axial test, and by a repeated measures ANOVA for the transverse test.

RESULTS

In the axial test, both neutral-zone laxity and flexibility were significantly increased by sectioning (p = 0.01 and p = 0.02, respectively).

In the transverse test, absolute value of neutral-zone laxity was largest in the 330°-120° direction before and after sectioning (Fig. 3). Increase of neutral-zone laxity was largest in the 300°-120° direction (averaging 1.52 ± 0.61 mm). Flexibility was largest in the 0°, 120°, and 150° directions in the intact. After sectioning, the increase of flexibility was largest in the 270° direction (Fig. 4).

DISCUSSION

Neutral-zone laxity reflects joint play. Experimentally, if neutral-zone laxity along a certain axis is increased by ITCL sectioning, it would suggest that, clinically, an ITCL failure would result in subtalar instability along that same axis. It also suggests the function of the ITCL as a primary restraint in one or both of two opposite drawer directions in the testing axis.

Flexibility reflects the joint resistance to applied force. Increase of flexibility indicates direction of resulting instability due to ITCL failure.

The transverse test showed that ITCL sectioning caused increased neutral-zone laxity and flexibility of the subtalar joint against forces applied to the calcaneus from lateral to medial. This result suggests ITCL failure may cause subtalar instability with rapid inversion forces.

Dominant direction for increased neutral-zone laxity was the axis running roughly from the posterior aspect of the lateral malleolus to the center of the medial malleolus, using bony landmarks. This direction is therefore regarded as the optimum direction for examining subtalar instability resulting from ITCL failure.

REFERENCES


Fig. 1: Drawer directions were defined per the motion of the calcaneus relative to the talus.

Fig. 2: Typical load-displacement responses, for a 300-120° direction transverse test, in intact condition.

Fig. 3 Neutral-zone laxity analysis for the transverse tests. *In the intact test, neutral-zone laxity for the 330°-150° direction was significantly larger than for any of the other directions (p-values < 0.04). **After sectioning, the 330°-150° direction was significantly larger than the other directions (p-values < 0.05), excluding the 300°-120° direction (p = 0.064). ¶ Increase of neutral-zone laxity for the 300°-120° direction was significantly larger than for any of the other directions (p-values < 0.05), excluding the 330°-150° direction (p = 0.067).

Fig. 4 Flexibility analysis for the transverse tests. ¶ Increase of flexibility due to ITCL sectioning for the 270° direction was significantly larger than for any of the other directions (p-values < 0.03).