ANKLE STABILITY: LIGAMENTOUS AND ARTICULAR RERAINTS

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INTRODUCTION:
Joint stability is a function of both the extrinsic elements such as ligaments and capsules as well as intrinsic elements such as geometry of the articular surfaces. Previous investigators examined the role of lateral ankle ligaments in stabilizing the ankle joint. Other factors, such as the effect of articular geometry, ankle position, and axial load are not clearly understood. A method for determining intrinsic joint stability as well as ligamentous contribution in the hand/wrist has been previously reported (1–3). The purpose of this study was to determine the contribution of ligaments and articular geometry to stability in the ankle joint.

MATERIALS AND METHODS:
Eight cadaveric lower extremities were studied. The specimens were disarticulated at the knee and at the mid-tarsal joints. Soft tissues including skin, subcutaneous tissues and muscles were dissected, maintaining integrity of ligaments and the interosseous membrane. The subtalar joint was immobilized in a neutral position by Steinmann pins and PMMA. Each specimen was mounted in a testing device, which enabled measurement of multi-axis force and displacement under axial, shear, and rotation loading (Figure 1). An additional X-Y horizontal stage that could be locked or released was placed beneath the motorized rotary and horizontal stages for alignment and positioning purposes. A low-friction vertical slide incorporating a bellows style pneumatic cylinder provided axial loading. Motor control and data acquisitions were accomplished using Labview (National Instruments, Austin, TX). Forces were applied to the talus in the direction of anterior-posterior and medial-lateral translation, and external-internal rotation both with an axial load equivalent to body weight (700N) and a minimal load (5N).

Testing was performed with the ankle in neutral, 10 degrees of dorsiflexion, and 15 degrees of planar-flexion. The intact ankle stability was first determined for all specimens. In four of the eight specimens the deltoid ligament was sectioned and the ankle retested, followed by the lateral ligament. This order was reversed in the remaining four specimens. The talus was displaced in a repeated fashion after ligament sectioning and restraining loads measured. These data were used to determine the contribution of the ligament or articular geometry to joint stability.

To determine the relative contribution of the ligaments and the articular geometry to resist joint motion, displacement values at 150N applied loads and rotational angular values at 250Ncm of torque were analyzed. At these positions the force after resection was compared to the intact to determine the contribution of each ligament (Fig 2).

Statistical analysis was performed with a paired t test or a repeated measures ANOVA with significance at p<0.05 level.

RESULTS:
Increasing the axial load resulted in reduced translation and rotation for both ligament intact and sectioned conditions. Ankle flexion position also had an effect on the displacement. For medial translation, displacement was significantly larger in plantarflexion than in dorsiflexion. For lateral translation, displacement was significantly larger in plantarflexion than in neutral and dorsiflexion in both loading conditions. For internal rotation, displacement was significantly larger in plantarflexion than in dorsiflexion.

Table 1 shows results for the calculated force contributions of the ligaments for the neutral position. Results are similar for both dorsiflexion and plantarflexion. At 700N, the articular geometry contributed 60 percent of rotational stability and 100 percent of translation stability.

DISCUSSION:
In the unloaded condition, the lateral collateral ligament was the primary restraint to anterior translation and the deltoid ligament the primary restraint to posterior translation. Both the ligaments contributed to external-internal rotation stability. However, the ligaments were not the primary restraints to medial-lateral translation. In the 700N axial loaded condition, the articular surface geometry was primarily responsible for ankle stability, especially in translation. This information is important for design and performance of ankle reconstruction operations such as ligament reconstruction and arthroplasty.

Table 1: Percent ligament contribution based on force reduction from intact at the neutral ankle flexion position. At 700N axial load level, all translation stability was due to articular geometry rather than ligaments.

<table>
<thead>
<tr>
<th>Ligament</th>
<th>Force Reduction (%)</th>
</tr>
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<tbody>
<tr>
<td>Lateral</td>
<td>5N</td>
</tr>
<tr>
<td></td>
<td>700N</td>
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<tr>
<td>Anterior</td>
<td>81.3(15.2)</td>
</tr>
<tr>
<td>Posterior</td>
<td>20.9(19.1)</td>
</tr>
<tr>
<td>Medial</td>
<td>39.9(19.2)</td>
</tr>
<tr>
<td>Lateral</td>
<td>21.3(21.6)</td>
</tr>
<tr>
<td>Internal</td>
<td>72.4(11.7)</td>
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</table>

**REFERENCES:**

***Hopital orthopedique de la Suisse romande

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