**Effect of Posttraumatic Tibiotalar Osteoarthritis on Kinematics of the Ankle Joint Complex**

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**Introduction:** Posttraumatic ankle osteoarthritis represents a disabling condition with treatment options being less successful than those available for hip and knee osteoarthritis. Surgical intervention, including tibiotalar arthrodesis and total ankle replacement (TAR), is a viable option when more conservative measures fail. However, altered gait mechanics and subtalar arthritis are well-established downsides of arthrodesis while risk of complication and early component failure have deterred many surgeons from TAR. Knowledge of joint kinematics in both the healthy and diseased joint is critical if joint replacement techniques and components are to be improved. To date, little is known about the effect of tibiotalar arthroplasty on kinematics of the hindfoot. This study investigated in-vivo kinematics of the ankle joint complex (AJC) during walking in patients with ankle joint arthritis using MRI and dual fluoroscopy.

**Materials and Methods:** Six patients (44 to 69 years of age) with end stage posttraumatic osteoarthritis of the ankle joint were recruited. The average time elapsed from the initial traumatic event was 17.4 years. All patients had unilateral involvement (3 right, 3 left). Patients with indwelling hardware in the ankle that was not compatible with magnetic resonance imaging (MRI) were excluded.

Each osteoarthritic ankle was MR imaged on a 1.5 T MRI scanner using a surface coil and fat suppressed T2 sequence with the subject lying supine. Sagittal images with a resolution of 512 x 512 pixels were taken at 1mm intervals. The MR images were imported into solid modeling software and digitized to outline the tibia, talus, and calcaneus (the ankle joint complex) to create 3D geometric models of the bones.

Two fluoroscopes with a resolution of 1000 x 1000 pixels were positioned to simultaneously capture the dynamic motion of the ankle joint complex during gait (Fig. 1). Each subject was asked to walk through the system while motion of the target ankle was recorded simultaneously by both fluoroscopes at a frame rate of 30 Hz. There was no strict positioning control across the subjects.

The 3D model of the AJC and the fluoroscopic images were imported into solid modeling software to re-create a virtual dual fluoroscopic system. The position of the tibia, talus, and calcaneus models were manipulated separately in six degrees of freedom until the projected outlines of the models simultaneously matched both fluoroscopic images. This process was executed at heel strike, midstance, and toe off for each subject. To describe the motion of the tibiotalar and subtalar joint, an anatomically based Cartesian coordinate system was used. The results were compared to kinematics of healthy ankles studied previously using MRI and dual fluoroscopy.

**Results:** During the stance phase of gait the osteoarthritic tibiotalar joint demonstrated 2.2±3.6° of internal rotation, 4.2±4.9° of dorsiflexion and 1.2±4.9° of eversion. The translation of the talus relative to the tibia was 0.1±0.2 mm distally, 0.4±1.3 mm laterally and 0.2±1.7 mm posteriorly.

Motion in the subtalar joint in patients with tibiotalar osteoarthritis during stance phase showed 0.5±5.8° of external rotation, 6.7±4.1° of dorsiflexion and 8.2±5.5° of eversion. Translation of the calcaneus with respect to the talus in the osteoarthritic cohort was 0.1±0.3 mm in the distal direction, 1.9±3.3 mm medially and 0.1±1.0 mm anteriorly (Table 1).

Range of motion of talocrural and subtalar joints during the stance phase of walking (heel strike to toe off). Numbers with asterisk (*) show statistically significant difference (p<0.05) between the motion of healthy ankles and ankles with posttraumatic talocrural arthritis.

**Discussion:** In the present study, a significant decrease in the range of motion in both the tibiotalar and subtalar joints was observed when compared to that of healthy ankles. Furthermore, on average, rotation in the sagittal, frontal and transverse planes were opposite of those observed in healthy ankles (p=0.00002, p=0.02, p=0.02 respectively). Motion coupling between the tibiotalar and subtalar joints seen in normal subjects was not demonstrated in patients with posttraumatic tibiotalar osteoarthritis. This data contributes to the understanding of the disease process and may ultimately help improve treatment options and prosthetic designs.

**References:** 1. Thomas RH, Daniels TR. Ankle arthritis. JBJS Am. 2003 May;85-A(5):923-36.


**Acknowledgements:** This study was funded by the Orthopaedic Research and Educational Foundation. The authors would also like to acknowledge Angela L. Moy NIH, Michele L. Weiser, Shaobai Wang, Jeremy F. Suggs, George R. Hanson, Ali Hosseini, Daniel F. Massimini and Ramprasad Pappan'gari for their technical assistance.

**Table 1:**

<table>
<thead>
<tr>
<th>Joint</th>
<th>DF/P (°)</th>
<th>ER/IR (°)</th>
<th>IV/EV (°)</th>
<th>A/P (mm)</th>
<th>V/P (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tibial OA</td>
<td>2.2±3.0</td>
<td>4.2±4.9</td>
<td>1.2±4.9</td>
<td>0.1±0.2</td>
<td>0.4±1.3</td>
</tr>
<tr>
<td>Healthy</td>
<td>3.1±1.4</td>
<td>6.7±4.1</td>
<td>8.2±5.5</td>
<td>1.9±3.3</td>
<td>0.1±1.0</td>
</tr>
<tr>
<td>Tibial OA</td>
<td>-0.5±5.8</td>
<td>-4.1±1.3</td>
<td>-8.2±5.5</td>
<td>-0.1±0.3</td>
<td>-1.9±3.3</td>
</tr>
<tr>
<td>Healthy</td>
<td>-0.5±5.8</td>
<td>-4.1±1.3</td>
<td>-8.2±5.5</td>
<td>-0.1±0.3</td>
<td>-1.9±3.3</td>
</tr>
</tbody>
</table>

**Fig. 1:** The dual-orthogonal fluoroscopic system setup for measurement of in-vivo ankle joint kinematics. The stance phase of walking was scanned from heel strike (top) to toe off (bottom).