In Vivo Segmental Foot Mobility during Walking and Step Descent in Patients with Midfoot Arthritis

In vivo segmental foot mobility was examined in 50 subjects with midfoot arthritis and 20 control subjects, matched in age, gender, and BMI. All patients with arthritis were diagnosed by an orthopaedic foot and ankle surgeon (Mean age: 62.4 years, Mean BMI: 29.6 ± 5.4) in accordance with IRB and HIPAA guidelines. Informed Consent was sought prior to initiating study procedures.

**METHODS**

**Subjects:** 50 subjects participated in this study, 30 with midfoot arthritis and 20 control subjects, matched in age, gender and BMI. All patients with arthritis were diagnosed by an orthopaedic foot and ankle surgeon (Mean age: 62.4 years, Mean BMI: 29.6 ± 5.4) in accordance with IRB and HIPAA guidelines. Informed Consent was sought prior to initiating study procedures.

**In Vivo Data Acquisition:** In vivo segmental foot motion was examined using a 5 segment model with previously established validity. Local co-ordinate systems were established by digitizing anatomical landmarks of interest. For walking trials, patients walked at self-selected monitored speed. To simulate stair descent, they stepped off a standard step height (15 cm) to the floor.

**Data Analysis:** Kinematic data were low-pass filtered using a fourth-order Butterworth filter with a cutoff frequency of 6 Hz and analyzed using MotionMonitor™ software. Euler angles, representing three sequential rotations (Z-Y-X) were used to describe joint motion. Peak values for all dependent variables were referenced to subtalar neutral: calcaneus eversion, forefoot abduction, 1st metatarsal plantarflexion and 1st metatarsophalangeal (MTP) dorsiflexion.

**Statistical Analysis:** A 2-way ANOVA was examined to see the effect of Group (Between-subjects effect) and Activity (Within-subjects effect) on all dependent variables.

**RESULTS**

**Figure 1.** Sensor setup and subsequent kinematic model

**Figure 2.** All subjects demonstrated significantly more peak 1st MTP dorsiflexion (p<0.01), ankle dorsiflexion (p<0.01), calcaneal eversion (p<0.03) and forefoot abduction (p<0.01) during step descent compared to walking.

**Figure 3.** All subjects demonstrated significantly greater total range of 1st MTP dorsiflexion (p<0.01), ankle dorsiflexion (p<0.01) and forefoot abduction (p<0.02) during step descent compared to walking.

**Figure 4a.** Group x Activity Interaction (p=0.02) During walking, patients with midfoot arthritis showed significantly less 1st Metatarsal plantarflexion range of motion compared to control subjects. However, in the step task, both groups showed similar 1st Metatarsal plantarflexion range of motion.

**Figure 4b.** Group x Activity Interaction (p=0.01) During walking, patients with midfoot arthritis showed similar calcaneus eversion range of motion compared to control subjects. However, in the step task, patients with midfoot arthritis showed significantly more calcaneus eversion range of motion compared to control subjects.

**CONCLUSIONS AND DISCUSSION**

- Step descent requires more 1st MTP dorsiflexion, ankle dorsiflexion, calcaneus eversion and forefoot abduction than walking. In addition, step descent also necessitates greater excursion (total range) of 1st MTP dorsiflexion, ankle dorsiflexion and forefoot abduction.

*Independently or in combination, these motions may contribute to articular stress and thus provoke symptoms.*

- Patients with midfoot arthritis responded differently to the step task compared to control subjects in their use of 1st metatarsal and calcaneus eversion range of motion. Increased 1st Metatarsal plantarflexion and calcaneal eversion range of motion in the step activity was noted in patients with midfoot arthritis

*The increased range of motion may be indicative of loss of midfoot stability in more challenging non-gait activities.*