**Introduction:** Knowledge of normal bone motion of the foot is important for understanding gait as well as for various pathologies; however, the 3D motion of these bones is not yet completely understood. The aim of this study was to quantify the in vivo motion of the talo-crural joint, talo-calcaneal joint, and talo-navicular joint in normal adult feet using a noninvasive measurement technique.

**Materials and Methods:** Computer tomography images were taken of the bilateral foot of ten normal young adults (6 males, 4 females) in neutral, plantar flexion, and dorsiflexion positions, from which 3D virtual models were made of each mid-hind foot bone. The 3D bone motion of these models was calculated using Euler angles and volume merge methods in three major planes (Fig. 1, 2) [1, 2]. For determining the Euler angles, three major axes of rotation, plantar flexion/dorsiflexion (pf/df), abduction/adduction (abd/add), eversion/inversion (ev/iv), were examined for each bone. From these data, we analyzed the relation between the motion of the foot and each joint, as well as the differences in gender.

**Results:** With the foot held in maximal dorsiflexion, talo-tibial joint rotation was in dorsiflexion (15.9±6.5°), abduction (5.5±2.9°), and eversion (7.2±3.1°). Talo-calcaneal and talo-navicular joint rotation was ambiguous. With the foot held in maximal plantar flexion, the talo-tibial joint rotation was in plantar flexion (41.7±5.4°) and adduction (13.6±5.6°). Talo-calcaneal rotation was ambiguous. Talo-navicular rotation was mostly in plantar flexion (7.0±7.3°) and inversion (Fig. 3).

The motion of three axes of the talo-tibial joint and the y-axis of the talo-navicular joint was associated with the foot motion (Fig. 3). The motion of three axes of the talo-tibial joint during plantar flexion, the range of motion in plantar flexion and inversion was wider in females than in males. However, at the talo-crural joint during dorsiflexion, the range of motion in abduction and eversion was wider in males (er, 8.5°; ev, 7.0°) than in females (er, 5.5°; ev, 2.5°) (Table 1).

**Discussion:** In the present study, a new noninvasive method using 3D computer models from CT images was introduced to measure in vivo midfoot and hindfoot rotation and translation.

The motion of the talo-tibial joint was nearly the same as the previous reports; however, the direction and range of motion of the talo-calcaneal joint or talo-navicular joint was different. We speculate that the joint play in the cadaveric studies was less than that in the in vivo studies because the tension of soft tissue, ligaments, and tendons differs between live bodies and cadavers [3].

In general, females have a wider range of motion of the feet and ankles than males [4]. Our study indicated that in adults, the range of motion of the frontal axis at the talo-calcaneal joint and talo-navicular joint was greater in females than in males. On the other hand, at the talo-crural joint during dorsiflexion, the range of motion in abduction and eversion was greater in males than in females. It is thought that males have a smaller range of frontal axis motion but a larger range of abduction and eversion with the foot held in dorsiflexion because the diameter of the lateral trochlea tali is smaller than that of the medial trochlea tali.

We could easily and accurately calculate bone motion using volume merge methods more effectively than other methods. The obtained data elucidates baseline segmental motion for comparison with symptomatic subjects.

**References:**