Load Response of Forefoot and Medial Longitudinal Arch Bones in Patients with Flatfoot Deformity: In Vivo 3D Study

Foot & Ankle Category: Midfoot / Forefoot

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Introduction
Measuring the load response of foot bones is important for the evaluation of clinical conditions or staging of foot diseases. However, there have been no three dimensional (3D) studies reported so far to evaluate the load response of forefoot and medial longitudinal arch bones with flatfoot deformity using CT images. Last summer, we reported 3D load response of the hindfoot bones in patients with flatfoot deformity at the 2011 AOFAS meeting. The purpose of this study is to evaluate the bone rotation of each joint in the medial longitudinal arch during weightbearing and compare the load response in healthy feet with that in flat feet by using the reconstructive 3D CT imaging techniques.

Methods
All patients provided written informed consent to participate in the IRB approved research. CT scans of 21 healthy feet (11 volunteers) and 21 feet with flatfoot deformity (11 patients) were taken in non-load followed by full-body-weight bearing load. The images of the six bones (tibia, talus, navicular, calcaneus, cuneiforms and first metatarsal bone) of the medial longitudinal arch were reconstructed into 3D models using CAD software. The volume merge method in three planes was used for calculating each bone-to-bone relative rotation of the medial longitudinal arch bones. The global x-y-z coordinate system was used to describe the orientation and position of bones. The data were analyzed using unpaired t-test. A significant difference was defined as p less than 0.05.

Results
The total relative rotations between non-load and full-body-weight bearing load were significantly larger in the flatfoot in comparison with the healthy foot in all joints and the largest rotation was recognized in the talonavicular joint (healthy foot: 4.9±2.8°; flatfoot: 7.0±3.4° average ± SD, p< 0.05), followed in order by talocalcaneal joint (healthy foot: 3.2±1.9°; flatfoot: 4.9±2.4°, p< 0.05), tibiotalar joint (healthy foot: 2.6±1.6°; flatfoot: 4.3±2.9°, p< 0.05), cuneo-1st metatarsal joint (healthy foot: 1.4±0.8°; flatfoot: 2.6±1.1°, p< 0.05) and naviculocuneiform joint (healthy foot: 1.4±0.9°; flatfoot: 2.0±1.1°, p< 0.05) (figure, the upper part). The cuneiform position difference to the load response relative to
the navicular in the naviculocuneiform joint in the flatfoot was 0.9 degree more dorsiflexed than that in the healthy foot and the difference was significant (healthy foot: 0.3±0.9°; flatfoot: 1.2±1.1°, p< 0.05). Significant difference was neither observed in the coronal plane (healthy foot: -0.6±0.7°; flatfoot: -0.8±1.0°, p=0.45) nor in the transverse plane (healthy foot: 0.3±0.9°; flatfoot: 0.2±1.0°, p=0.79). The 1st metatarsal position difference to the load response relative to the cuneiform in the cuneo-1st metatarsal joint was 1.0 degree more dorsiflexed (healthy foot: 0.8±0.9°; flatfoot: 1.8±1.0°, p< 0.05). Significant difference was neither observed in the coronal plane (healthy foot: -0.4±0.9°; flatfoot: -0.7±1.4°, p=0.39) nor in the transverse plane (healthy foot: 0.0±0.6°; flatfoot: 0.4±1.1°, p=0.19) (figure, the lower part).

Conclusion
In the peritalar joints, the total rotations were larger than the other joints of medial longitudinal arch. In the flat feet, forefoot bones dorsiflexed more significantly than those in the healthy feet. Some procedures including forefoot might be needed to deal with the reconstruction of the flatfoot deformity.