ASSESSMENT OF TALUS DEFORMITY BY THREE DIMENSIONAL MRI IN CONGENITAL CLUBFOOT
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[INTRODUCTION]
The tarsal bones of infants are not completely ossified and are mostly cartilaginous, it has been difficult to assess the morphology and alignment of individual tarsal bones during infancy. In 1999, Cahuzac and colleagues performed three-dimensional magnetic resonance imaging (3-D MRI) to obtain continuous data, and assessed alignment anomalies of the tarsal bones using reconstructed images, but they did not discuss the morphological abnormality of individual tarsal bones. In the present study, we compared normal feet to clubfeet using talar morphological abnormalities associated with clubfoot. When clarifying morphological abnormalities, the talar head, neck and body must be identified. However, because the talus is predominantly formed from cartilaginous tissue during infancy, identification of these structures is difficult. By comparing the position of the talonavicular joint surface in relation to the entire talus between normal foot and clubfoot, we examined the morphological abnormalities associated with clubfoot.

[PATIENTS AND METHODS]
Subjects were two boys and three girls, with unilateral congenital clubfoot. MRI was performed of both feet at the age of 3 to 9 months (average: 5 months). MRI was performed using 1.5-Tesla magnetic resonance imaging (MAGNETON Vision Plus, Siemens, Germany) under the following conditions: 3D-FLASH, repetition time 48 msec, echo time 11 msec, flip angle 45°, slice thickness 1 mm, and matrix 256x256.

Based on the resulting MRI volume data, images of each tarsal bone were extracted based on their cartilage topography using Virtual Place-M Software, which was developed by our colleague (Medical Imaging Laboratory, Tokyo, Japan).

Subsequently, using the resulting volume images, Visualization Tool Kit (VTK) (Kitware Inc., New York, USA) was used to reconstruct three-dimensional surface bone model. The long axis of the resulting reconstructed model was determined, and in relation to the standard planes including this axis, the following parameters were compared between normal foot and clubfoot: the degree of talar head and neck deviation, talar volume.

Measurement of talar head and neck deviation: Three standard planes were established for the talus model. Plane X was defined as a plane parallel to the tibial bone axis, passing through the principal axis, while Plane Y was defined as a plane perpendicular to Plane X and including the principal axis of inertia. Additionally, Plane Z was defined as a plane perpendicular to both Planes X and Y (Fig. 1 b). Next, in order to determine a vector indicating the axial direction of the talar head and neck within the talus model, the following analysis was carried out by assuming the talonavicular joint to be spherical: Data were selected from the head and neck region and the body region with respect to the anterior margin of the trochlea of the talus to calculate volume ratios; the volume of the ossific nucleus for the clubfoot was 42.6% smaller than that for the normal foot (Table 2).

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RESULTS
The average medial talar neck angle for the normal foot was -9.1±7.8° (range: -21.3° - 0.2°), while that for the clubfoot was 9.2±5.2° (range: 0.3° - 12.9°) (Table 1). The talar head and neck angle in relation to the talus exhibited significant medial deviation in the clubfoot (p<0.05).

The average talar volume for the normal foot was 2957±608 mm³, while that for the clubfoot was 20.7% smaller at 2345±587 mm³ (p=0.013). The average volume of the head and neck region and the body region for the clubfoot was 787±243 and 1488±345 mm³, respectively, while those for the clubfoot were 787±243 and 1488±345 mm³. The volume of the ossific nucleus for the clubfoot was 42.6% smaller than that for the normal foot (Table 2).

DISCUSSION
Using 3-D MRI data, we can assess the volume of talus in vivo. The morphological characteristics of the talus were clarified by applying a 3-D MRI assessment technique to assess congenital clubfoot. Our findings showed that a clubfoot could be characterized by hypoplasia and medial deviation of the talar head and neck, when compared to a normal foot. The assessment technique presented herein was therefore shown to be useful in ascertaining the various pathological characteristics associated with clubfoot.

REFERENCES

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