Trabecular bone volume fraction (TBVF) measurements of 108 young children using a compact MRI

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Introduction

Bone density measurements are indispensable for studies of skeletal developments in childhood. MRI has several advantages in bone density measurements over conventional methods such as DXA (dual X-ray energy absorptiometry) and QUS (quantitative ultrasound): no ionic irradiation, 3D localization capability, and clear physical meaning. Whole body MRI scanners are, however, not suitable for bone density measurements of children because they usually have a fear to enter the bore or gap of the MRI magnet. The compact MRI developed for heel measurements [1] is very useful for bone density measurements of children because they can have MRI examinations while sitting on a chair in a open space with their heels in the gap of the small magnet. In the present study we measured trabecular bone volume fraction (TBVF) of the calcaneus for 108 young children to demonstrate the effectiveness of the compact MRI as a bone density measurement tool.

Materials and Methods

108 young children (age:2-12) participated in this study. After the informed consent of their parents was obtained, MRI and QUS measurements were performed for the right calcaneus. A compact dedicated MRI with a 0.21 T and 16 cm gap permanent magnet was used for the MRI measurements [1]. During the MRI examinations the subjects sat on a chair placed just in front of the magnet with their right heels in the RF probe box as shown in Fig.1. Their one of parents sat beside them to relax them during the examination for children under six years old.

Two 2D single spin-echo sequences (slice thickness 5mm, TR/TE = 1200ms/12ms, 1200ms/96ms) were used to measure T_2 and density of the bone marrow protons with external oil phantoms. The total measurement time for the two 128 × 128 pixel images was about 2.5 minutes, because the doubly zero-filled interpolation technique was applied for the 64-step phase encoding direction. TBVF was calculated in a square ROI shown in Fig.2. SOS measurements were performed using a commercially available QUS instrument (AOS-100: ALOKA).

Results and Discussion

Table 1 shows R^2 between two kinds of TBVF and SOS (speed of sound), and age, height, and weight. The first kind of TBVF was calculated from two spin-echo images acquired with TE = 12 ms and 96 ms. The T_2 weighted images (TR/TE=1200ms/96ms) were, however, in many cases severely affected by motion artifacts. Thus the first kind of TBVF was able to be calculated only for 40 children. The second kind of TBVF was calculated under the assumption that T_2 was constant for healthy subjects [2]. We thus calculated this kind of TBVF from a constant T_2 value (83.3 ± 3.0ms: average and SD value for 40 children who gave no motion artifacts on their T_2 weighted images) and one spin-echo image with TE = 12 ms. However, not a few children gave severe motion artifacts even on the proton density weighted images. As a result the second kind of TBVF was able to be calculated for 69 subjects. As shown in the Table 1, SOS failed to measure the bone status of the children probably because the diameter of the ultrasound probe was larger than the calcaneus of the children.

Figures 3, 4, and 5 show the correlations between the second kind of TBVF and age, height, and weight for 69 children. These figure clearly show positive correlations between TBVF and age, height, and weight, respectively.

In conclusion the compact MRI is a very useful and may be exclusive tool for bone density measurements of young children.

Fig.1 RF probe and foot

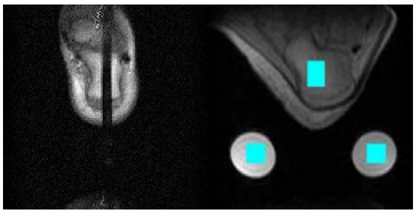

Fig.2 Heel cross section

	Age	Height	Weight
TBVF from two spin-echo images	0.25	0.24	0.22
TBVF from a constant T_2	0.23	0.31	0.31
SOS	<0.01	0.01	0.02

Table 1 Correlation coefficient (R^2)

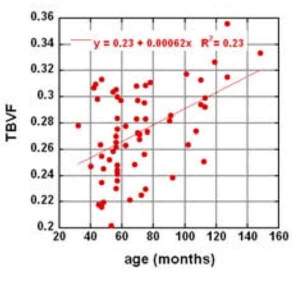

Fig.3 Age vs TBVF

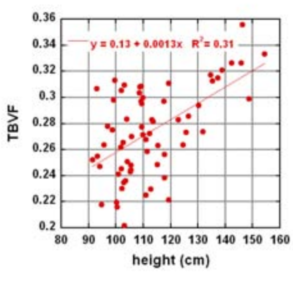

Fig.4 Height vs TBVF

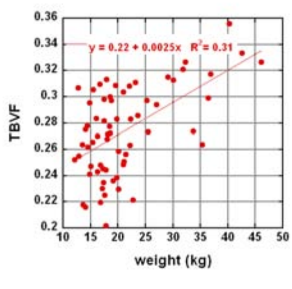

Fig.5 Weight vs TBVF

References

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