3D heterogeneity measurements of the calcaneal trabecular bone density using a Compact MRI

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Abstract

3D spin-echo images of the calcaneus were measured for eight healthy female volunteers using a dedicated compact MRI. Bone density calculated from the 3DSE images for sagittal slices showed nearly linear decrease from the interior to the exterior of the calcaneus. The result demonstrated that selection of a sagittal plane is very important for MRI bone density measurements.

Introduction

The calcaneus is one of the best bones for bone density measurements, because it consists almost of trabecular bone, transmission measurements (ultrasound, X-ray) is easily performed, and it has a reasonable size for small detectors (ultrasonic transducers, small RF coils). Density of the calcaneal trabecular bone, however, is observed to be heterogeneous, at least in the sagittal sections [1,2]. In the present study, we measured heterogeneity of the trabecular bone density perpendicular to the sagittal plane using a dedicated compact MRI [3] and found its nearly linear decrease from the interior to the exterior direction.

Material and methods

Right calcanei of eight healthy female volunteers (age: 22-24, mean 22.5) were used for this study. 3D TBVF (trabecular bone volume fraction) measurements were performed with a dedicated compact MRI using a 0.21T, 16 cm air-gap permanent magnet [3]. 32 contiguous sagittal slices were obtained using a 3D spin-echo sequence: TR/TE=600ms/12ms, FOV: 128 mm x 128 mm x 32 mm, matrix size: 128 x 128 x 32. The total scan time was about 21 minutes, because the doubly zero-filled interpolation technique was applied for the 64-step phase encode direction.

Results and Discussion

Figure 1 shows a sagittal image (center) and two cross-sectional images (left and upper) perpendicular to the sagittal image of a calcaneus. In the sagittal image, heterogeneity of the trabecular bone was observed as reported already [1,2]. To obtain TBVF distribution from the 3D-SE images, we made the following assumptions: T_1 and T_2 of protons in the bone marrow are constant over the calcaneus, and static magnetic field, magnetic field gradients, and RF field are homogeneous over the imaging region in the calcaneus. Under the above assumptions, we evaluated relative TBVF variations for contiguous sagittal sections.

Figure 2 shows relative TBVF integrated over a common square ROI (Fig.1) in the sagittal sections and plotted along the direction perpendicular to the sagittal plane. As seen from the figure, all of the TBVF show nearly linear decrease from the interior to the exterior in the calcaneus. The difference between the maximum and minimum of the TBVF varied from 1.7 to 12.5% for eight subjects. This result shows that a sagittal plane should be carefully selected for MRI bone density measurements.

Conclusion

3D SE measurements of the calcaneus have demonstrated nearly linear TBVF decrease from the interior to the exterior direction in the calcaneus. This result shows that selection of a sagittal plane is very important for MRI bone density measurements.

References

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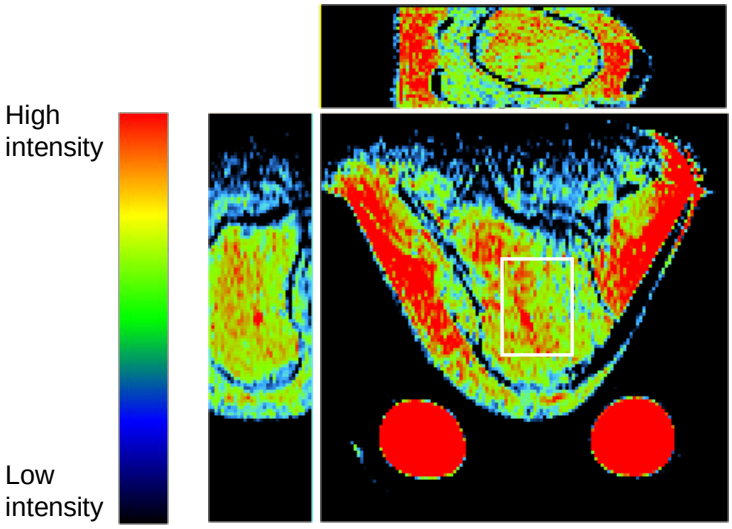

Fig.1 2D cross sectional images selected from a 3D image dataset acquired and ROI (the white square) with a 3DSE sequence. Central: sagittal image, upper: horizontal slice, left: vertical slice.

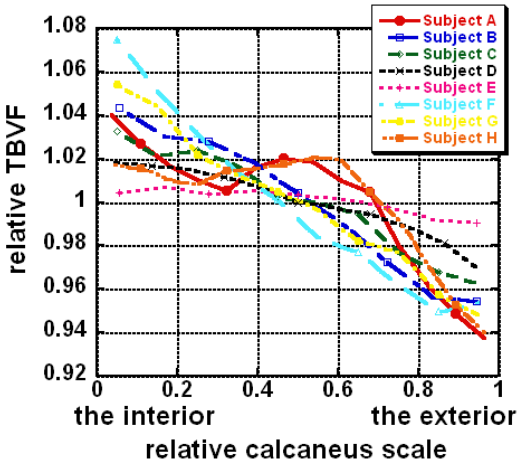

Fig.2 Relative TBVF variations integrated over a common ROI for contiguous sagittal slices. The horizontal direction is from the interior to the exterior of the calcaneus. Moving average for five slices were performed.