In vivo assessment of trabecular bone microstructure of the distal radius using a compact MRI

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Introduction

Measurements of trabecular bone (TB) microstructure are essential for estimation of bone strength and evaluation of drug therapies against osteoporosis. *In vivo* high resolution MRI is a powerful tool for TB microstructure measurements. Several groups have been studied it using whole body MRI (WB-MRI) systems, dedicated RF coils, and sophisticated pulse sequences (1,2). However, the WB-MRI systems are not cost effective and require large installation spaces. To solve these problems, dedicated MRI systems are desired. We have developed a compact MRI for TB microstructure measurements of the distal radius and the calcaneus using a 1.0 T permanent magnet (3). In this study, we have demonstrated the usefulness of the compact MRI system for measurements of the TB microstructure in the distal radius.

Materials and Methods

One male subject (25 yo) was used for experimental evaluation. A compact MRI developed for TB microstructure measurements of the distal radius and the calcaneus was used (Fig.1) (3). The distal radius of the nondominant hand was measured using a slice selective 3D driven-equilibrium spin echo (3D-DESE) sequence (TR/TE = 80 ms/10 ms, NEX = 2, acquisition time 22 min, matrix size: 512× 256 × 32, FOV: 76.8 mm × 38.4 mm × 16.0 mm). The acquired image datasets were reconstructed using a 1024× 512 × 128 voxel Fourier transform. Therefore, the spatial resolution and the voxel size were 150 × 150 × 500 micron cube and 75 × 75 × 125 micron cube, respectively. Apparent marrow volume fraction (app.MVF) mapping was performed using a local marrow intensity derived from the image data. The local marrow intensity $I_{m,local}(r)$ was calculated as the most occurring intensity greater than the mean intensity of a local volume of interest(4). The *app.MVF(r)* was calculated by dividing the measured voxel intensity $I_{meas}(r)$ by the local marrow intensity $I_{m,local}(r)$:

$$app.MVF(r) = I_{meas}(r) / I_{m,local}(r) \quad , \quad app.BVF(r) = 1 - app.MVF(r)$$

We assumed that the voxel intensities in the app.MVF map greater than 100% were pure bone marrow voxels. Bone structure parameters were calculated for app.MVF map consisting of 26 consecutive slices located between 10 mm and 13.25 mm from the distal end of the radius, using a commercial software package (TRI/3D-BON, Ratoc System Engineering, Tokyo, Japan).

Results and Discussion

Figure 2 shows an axial 2D image of the distal radius obtained from the 3D image datasets acquired with the slice selective 3D-DESE sequence. Fig 3 and 4 show the local marrow intensity $I_{m,local}(r)$ and the *app.MVF(r)* (average app.MVF = 0.82). By analyzing the bone microstructure using the *app.MVF(r)*, we obtained app.BV/TV = 22.2 %, app.Tb.Th = 228μm, app.Tb.Spac = 511 μm. These results demonstrate that we can obtain 3D microstructure parameters and TB density characterizing mechanical status of the bone using the compact MRI.

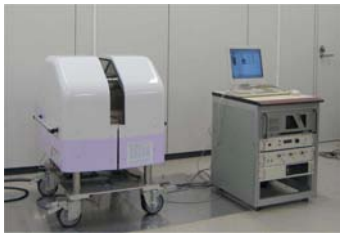

Fig.1 System overview

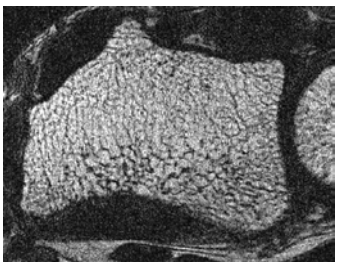

Fig.2 $I_{meas}(r)$

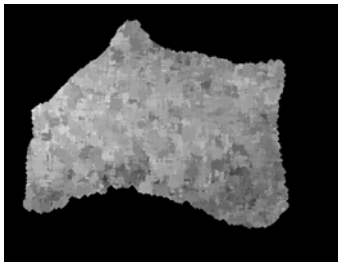

Fig.3 $I_{m,local}(r)$

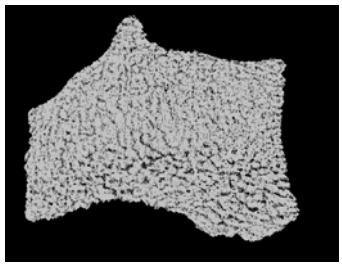

Fig.4 *app.MVF(r)*

Conclusions

TB microstructure of the distal radius was measured using the compact MRI system. Although further improvements in image processing will be needed, our system has a promise for an assessment tool of TB microstructure.

References

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