Reproducibility of bone microstructure parameters measured with a compact MRI for a finger

N. Iita[1], S. Handa[1], S. Tomiha[1], K. Kose[1], and T. Haishi[2]

[1]Institute of Applied Physics, University of Tsukuba, Tsukuba, Ibaraki, Japan, [2]MRTechnology Inc., Tsukuba, Ibaraki, Japan

Introduction

Trabecular bone (TB) microstructure measurements using high resolution MRI (HR-MRI) are essential for estimation of bone strength and evaluation of drug therapy against osteoporosis (1,2). Such measurements have been performed using whole body MRI and compact MRI with small permanent magnets (1-4). When these systems are used for longitudinal studies such as evaluation of drug therapy, reproducibility of the measurements should be critically evaluated (5,6). In this study we scanned two subjects repeatedly using a compact MRI for a finger to evaluated the reproducibility of the bone structure parameters.

Materials and Methods

Two subjects (A: 53 aged man, B: 45 aged woman) were used for MR measurements. A compact MRI system with a 1.0 T permanent magnet was used for TB microstructure measurements of the finger (3). The middle finger of the subjects was scanned using a 3D driven equilibrium spin echo sequence (TR = 50 ms, TE = 6 ms, FOV = $(20.48\ \text{mm})^3$). Subject A was measured 11 times consecutively with the finger fixed at the same position. Subject B was measured 25 times independently in four days after repositioning. The data acquisition matrix was $112 \times 128 \times 128$ and $128 \times 128 \times 128$ for subjects A and B. The acquisition time for one 3D image dataset was about 14 and 16 minutes for subjects A and B.

The acquired image datasets were reconstructed using a $256 \times 256 \times 256$ voxel Fourier transform. Therefore, the spatial resolution and the voxel size were ~$(160\mu\text{m})^3$ and $(80\mu\text{m})^3$, respectively. BVF (bone volume fraction) was calculated using a histogram deconvolution technique including the partial volume effect (7). Bone structure parameters were calculated for 3D image datasets consisting of 30 consecutive slices located between 1.5 mm and 3.9 mm from the distal end of the middle phalanx, using a commercial software package (TRI/3D-BON, Ratoc System Engineering, Tokyo, Japan).

Results and Discussion

Figure 1 shows fitted curves for image intensity histograms in a parallelpiped region (about 70,000 voxels included) located in the TB area of the finger. We defined a successful scan as that gave a histogram with two separated peaks for bone and bone marrow. All scans were successful for subject A and 19 scans were successful for subject B, because the spatial resolution was very sensitive to the motion of the finger. Figures 2 and 3 show time sequences of BVF calculated in parallelpiped regions in the TB area plotted for successful scans of subjects A and B. The CV (coefficient of variance) of the BVF was 3.5% and 4.7 % for subjects A and B. Mean and CV for other bone structure parameters are shown in Table 1. The CV values varied from 0.7% to 9.5%.

Because the image quality is seriously affected by the finger motion, the key to success of the finger scan is immobilization of the finger. In addition to immobilization, some image matching technique will improve CV values because the position of the finger for subject B was slightly different for every scan.

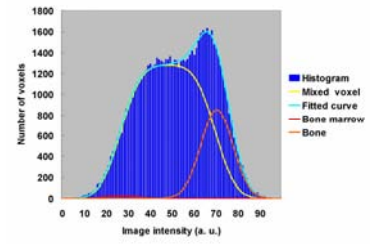

Fig.1

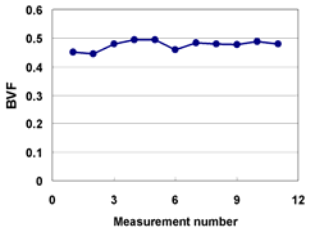

Fig.2

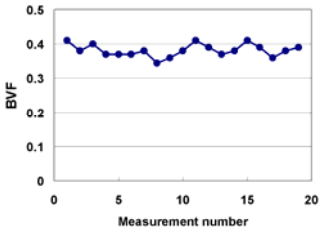

Fig.3

		Mean	CV
Subject A	BV/TV(%)	25.81	6.6 %
	Tb.Th(μm)	219.19	2.7 %
	Tb.N(1/mm)	1.20	9.5 %
	Tb.Sp(μm)	256.88	2.2 %
	Tb.Spac(μm)	476.08	0.9 %
Subject B	BV/TV(%)	33.5	8.1 %
	Tb.Th(μm)	225.49	3.3 %
	Tb.N(1/mm)	1.18	7.8 %
	Tb.Sp(μm)	261.06	3.1 %
	Tb.Spac(μm)	486.55	0.7 %

Table 1

Conclusion

Reproducibility of the TB microstructure measurements was evaluated using two subjects with different protocols. CV of bone structure parameters varied from 0.7% to 9.5%. Immobilization of the finger is essential but image matching technique will improve the CV.

References

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