In-vivo MR microscopy of trabecular structure of a human finger using a small permanent magnet

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Introduction

In-vivo MR microscopy has been used to measure trabecular bone architecture for characterizing the mechanical status of the bone. Up to now, whole body MRI scanners or high-field superconducting animal MRI systems have been used for this purpose [1-4]. Use of such systems are, however, not cost effective and require a large installation space. In the present study we have developed an MR microscope for a human finger to overcome these disadvantages.

Materials and Methods

Figures 1 and 2 show a portable MR microscope and a permanent magnet developed in this study. The installation space for the MR microscope is 1.0 m × 0.6 m. The specification of the magnet is; field strength: 1.0 T, gap width: 40 mm, homogeneity: 13 ppm over 13 mm dsv, size: 27cm(W) × 18cm(H) × 24cm(D), weight: 85kg. Magnet temperature was regulated within 33±0.1° to suppress Larmor frequency drift. A flat gradient coil set (efficiency: 6.7, 6.8, and 5.0 G/cm/A for G_x, G_y, and G_z) and a trapezoidal RF probe box (Fig.3) were developed for a human finger. The RF coil was a 28 mm diameter seven-turn solenoid. A 3D spin-echo sequence (TR/TE = 100ms/12ms, image matrix: 128^3, voxel size: 192 μm^3) was used for 3D MR microscopic imaging of a human middle finger (total imaging time: ~27 min.).

Results and Discussion

Figures 4 and 5 show transverse and coronal cross-sections selected from a 256^3 voxel 3D image dataset of a middle finger. This dataset was obtained through a zero-filled Fourier interpolation of the 128^3 voxel image described above. The image voxel size was thus 96 μm^3. A 5.2mm × 2.1mm × 2.7mm square region displayed on Figs.4 and 5 was cut from the 3D image of the middle finger. Figure 6 shows the histogram of the image intensity for this region. This histogram clearly shows that the number of voxels for the trabecular bone can be counted using a curve fitting. Figure 7 shows a histogram of image intensity calculated for another square region filled with bone marrow within the cortical bone. Because the horizontal axis of Figs.6 and 7 is identical, this figure shows that the image intensity of the bone marrow was homogeneous and affected only by thermal noise. A surface rendered 3D image of the trabecular bone in the region displayed on Figs.4 and 5 is shown in Fig.8.

At present, although the pulse sequence has not been optimized and the imaging time (~27 min.) may be long for routine bone examination, this system has a promise as a bone examination tool.

Fig.1 Portable MRM

Fig.2 Permanent magnet

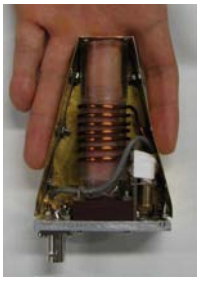

Fig.3 RF probe

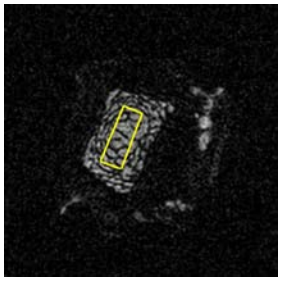

Fig.4 Transverse section

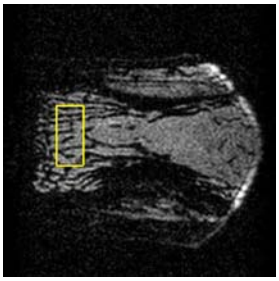

Fig.5 Coronal section

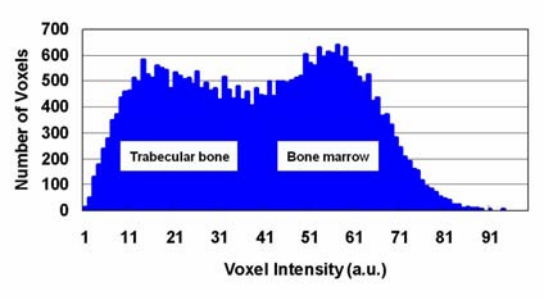

Fig.6 Histogram at trabecular region

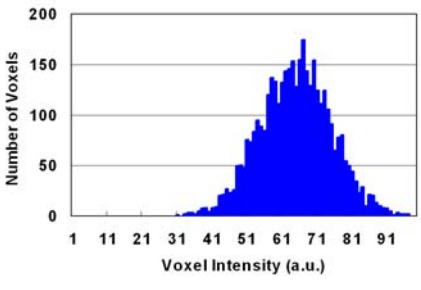

Fig.7 Histogram at bone marrow

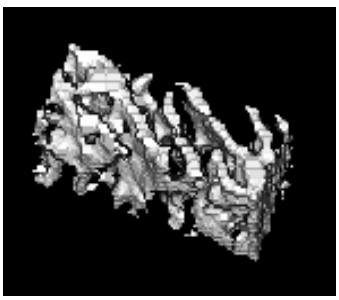

Fig.8 Surface rendered 3D image

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