MR Microscopy of Chemically Fixed Human Embryos with a Large Image Matrix

Y. Otake[1], S. Handa[1], K. Kose[1], K. Shiota[2], S. Yamada[2]

[1]Institute of Applied Physics, University of Tsukuba, Tsukuba, Ibaraki, Japan, [2]Center for Congenital Anatomy Research, Kyoto University, Kyoto, Kyoto, Japan

Introduction

There are only a few reports on MR microscopy of human embryos because it is very difficult to obtain specimens. Duke University reported 3D MR microscopic images of human embryos at various developmental stages using a 128 × 256 × 256 image matrix (1). Our group recently reported 3D MR microscopic images of 1,204 chemically fixed human embryos selected from the Kyoto Collection of Human Embryos (2-4). The number of image matrix for these images was, however, limited to 128 × 128 × 256 voxels primarily because of the magnetic field strength (2.34 T) used for the image acquisition. In the present study we developed a 9.4 T MR microscope with a wide dynamic range (~81dB), and acquired 3D MR microscopic images of human embryos using a 256 × 256 × 512 image matrix.

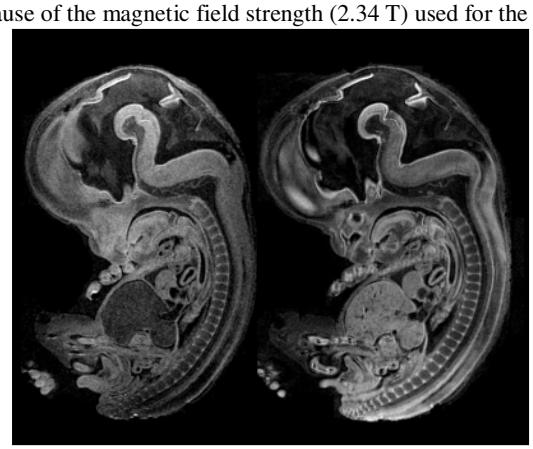

Fig.1 60μm^3 voxel resolution chemically fixed human embryo with spin-echo (left) and gradient-echo (right).

Materials and Methods

Carnegie Stage (CS) 16 to 22 human embryos were selected from the Kyoto Collection of Human Embryos (5). The specimens were stored in NMR sample tubes filled with formalin solution and used for MR microscopy measurements. The MR microscope was developed using a 9.4 T vertical wide bore (89 mm) superconducting magnet (JASTEC, Kobe, Japan), a home-built gradient probe, and a MRI console developed in our laboratory. The MRI receiver system consisted of two MRI receivers (DTRX4, MRTechnology, Tsukuba, Japan) with different gain (typically 37dB(spin-echo) / 33dB(gradient-echo) difference). NMR signals were simultaneously acquired using the two receiver channels, and MRI datasets in the k-space were synthesized from those acquired with the two channels (6). 3D spin-echo (TR=100ms, TE=12ms) and gradient-echo (TR=100ms, TE=5ms) pulse sequences were used for the 256 × 256 × 512 voxel image acquisition.

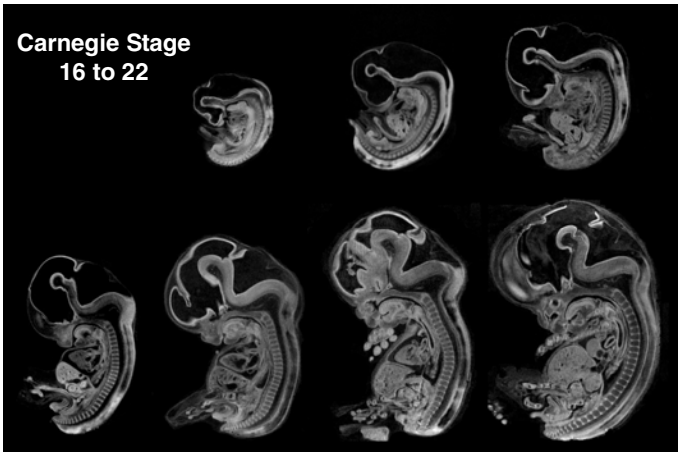

Fig.2 Mid-sagittal cross sections of CS16 to CS22 human embryos. Voxel size is 40 μm^3 in CS16-17, 50μm^3 in CS18-19, 55μm^3 in CS20, and 60μm^3 in CS21-22.

Results

Figure 1 shows mid-sagittal cross sections of a CS22 embryo acquired with the spin-echo and gradient-echo sequences. Difference in image contrasts is clearly observed. Figure 2 shows series of mid-sagittal cross sections of CS16 to CS22 human embryos. Developments of internal structures are clearly visualized. Figure 3 shows cross-sections of the livers acquired with the gradient echo sequence. Developments of vascular structures are clearly visualized with the T_2* contrast of the blood.

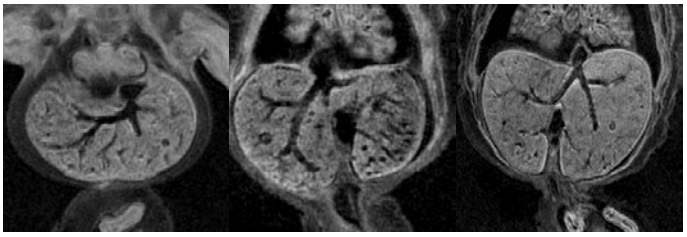

Fig.3 Cross sections of livers of CS17 (left), CS20 (center) and CS22 (right).

Discussion

To obtain clear large-matrix MR microscopic images, a high SNR and a wide signal dynamic range are required. We solved these problems using a 9.4 T superconducting magnet and parallel receivers. The presented results demonstrated the effectiveness of our system.

In conclusion, large matrix and high resolution MR microscopic images of human embryos were acquired using a high magnetic field and a parallel receiver system, and various structures of the embryos were clearly visualized.

References

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