3D visualization of organs in chemically fixed human embryos acquired with microscopic spatial resolutions

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Introduction

Kyoto university has a large collection (~50,000) of chemically fixed human embryos (Kyoto Collection of Human Embryos) systematically collected in 1960's [1]. Because such a collection will never be obtained again, we started a project to acquire 3D MR microscopic images of 1,204 chemically fixed human embryos selected from the collection using a super-parallel MR microscope to make an anatomical database of human embryos [2-4]. The number of image matrix for these images was limited to $128 \times 128 \times 256$ voxels primarily because of the magnetic field strength (2.34 T) used for the image acquisition. After the project, we extended the image matrix size to $256 \times 256 \times 512$ using a 9.4 T MR microscope developed in our laboratory and acquired image datasets of several human embryos [5]. In this study we developed a method to visualize 3D structure of organs in the chemically fixed human embryos acquired with the microscopic spatial resolution to demonstrate a potential of the large matrix embryo image datasets.

Materials and Methods

Carnegie Stage (CS) 16 to 22 human embryos were selected from the Kyoto Collection of Human Embryos [1]. 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, a home-built gradient probe, and a MRI console developed in our laboratory [6]. Heavily T_1-weighted 3D spin-echo (TR=100ms, TE=12ms) and gradient-echo (TR=100ms, TE=5ms) pulse sequences were used for the $256 \times 256 \times 512$ voxel image acquisition.

Organs to be visualized were extracted using a region growing technique and an interactive GUI tool. The extracted 3D region was visualized using a 3D visualization software package (Volume-One).

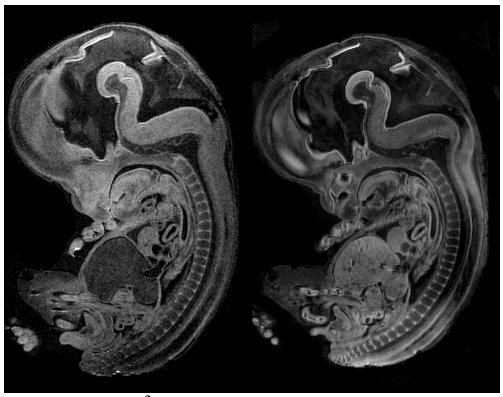

Fig.1 $60\mu m^3$ chemically fixed human embryo with spin-echo (left) and gradient-echo (right).

Results and discussion

Figure 1 shows mid-sagittal cross sections of a CS22 embryo acquired with the spin-echo and gradient-echo sequences. Figure 2 shows contiguous horizontal cross-sections of the CS22 embryo acquired with the gradient echo sequence including the liver used for 3D visualization. The boundary of the liver is clearly visualized with the T_1 and T_2* contrast. Figure 3 shows a maximum intensity projection of the extracted region of the liver calculated after the image intensity was reversed. Vessel structure is clearly visualized with T_2* contrast. This result demonstrates that the large matrix image datasets of the embryos can be used for 3D extraction and visualization of organs if the image contrast is optimized. 3D visualization of organs extracted from human embryos at various developmental stages will be a great help in understanding the human development.

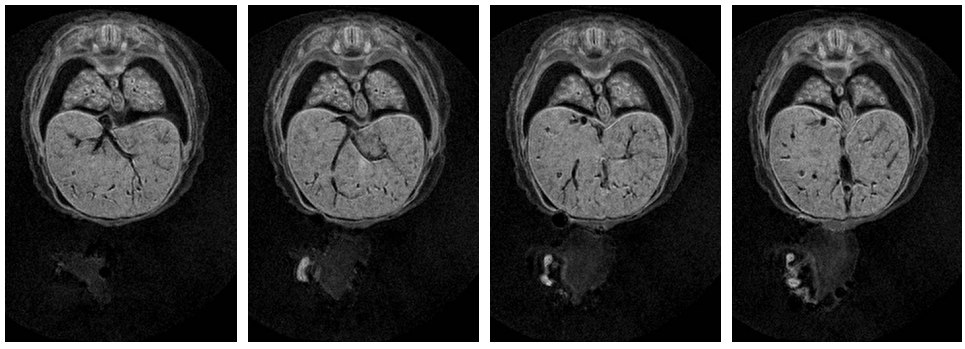

Fig.2

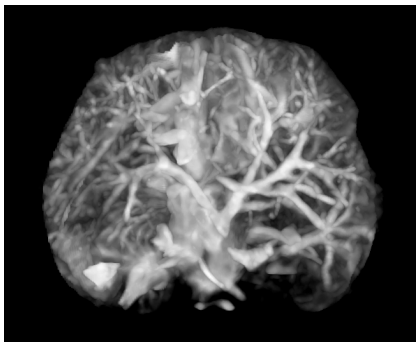

Fig.3

References

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