3D MR microscopy of a large human embryo collection (Kyoto collection) to create a 3D image database for human embryology

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Abstract

An efficient (four-channel super-parallel) MR microscope was developed for 3D MR microscopy of 2,000 chemically fixed human embryos. About 500 embryos were already measured at about $(100\mu m)^3$ isotropic spatial resolution. The 3D image datasets were demonstrated to be useful for studies in human embryology.

Introduction

Kyoto University has a large human embryo collection (~50,000 specimens), which were collected from 1961 to 1974 [1]. Because such a collection will never be obtained again, their nondestructive 3D measurements are highly desired. Kyoto and Tsukuba Universities have therefore started a project acquiring 3D MR microscopic images of about 2,000 embryos in two years to create a 3D anatomical database for human embryology.

Materials and methods

Human embryo specimens were chemically fixed in Bouin's fluid and stored in 10% formalin solution [1]. Among about 50,000 preserved embryos, about 2,000 undamaged specimens, ranging from Carnegie stage 13 to 23, were selected for the project. Because Tsukuba and Kyoto Universities are 500 km apart, specimens were transported in NMR sample tubes filled with the formalin.

The embryos were imaged in the formalin to avoid susceptibility effect, with a four-channel super-parallel MR microscope [2,3] using a 2.34 T / 40 cm superconducting magnet. All of the 19th, 20th, and 21st stage embryos (about 150 specimens for each stage) were measured using a T_1 weighted 3D SE sequence (TR/TE = 100ms / 10ms).

Results and discussion

Figure 1 shows mid-sagittal images selected from 3D image datasets of 19th, 20th, and 21st stage human embryos acquired with the T_1 weighted sequence. The image matrix is 128 x 128 x 256 and the voxel size is $(100\mu m)^3$ for the 19th and 20th embryos, and $(120\mu m)^3$ for the 21st stage embryo. The number of signal accumulations was 16 and the total imaging time was about 7.5 hours. Figure 2 shows a 3D image of a liver extracted from a 3D dataset of a 21st embryo. Figure 3 shows liver volumes measured for the 19th, 20th, and 21st embryos (n=4 for each stage). This graph clearly shows a linear increase of the liver volume with the developmental stage. This result demonstrates usefulness of the anatomical image database in human embryology.

We can measure eight embryos per day using the super-parallel MR microscope and perform measurements of 150 embryos in about one month. The protocol which we established is now used for the two-year-project for 3D imaging of the 2,000 embryos.

Conclusions

We have developed an efficient MR microscope for imaging a large number of human embryos and established a protocol to acquire 3D image datasets of 2,000 human embryos in two years. The anatomical image database is very useful in human embryology. This project is a collaborative work with professors Kohei Shiota and Tetsuya Matsuda at Kyoto University.

References

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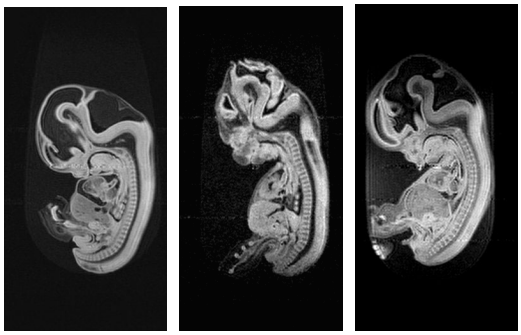

Fig.1 19th, 20th, and 21st embryos.

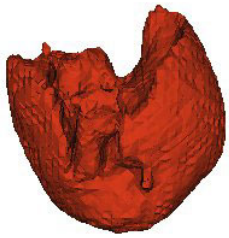

Fig.2 Extracted embryo's liver.

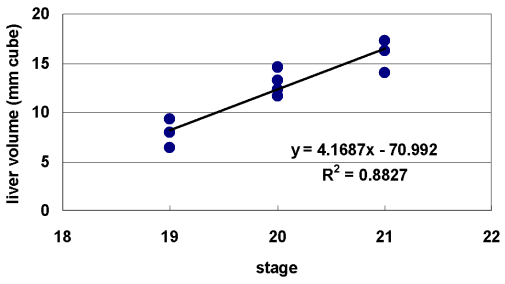

Fig.3 Liver volume vs. stage (n=4)