# Three Dimensional Magnetic Resonance Imaging of the Fetal Brain in Utero

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Introduction: In our study we used images from single shot fast spin echo (SSFSE) sequences of the fetal brain in utero to reconstruct three-dimensional (3D) models of the fetal brain. The 3D visualization of fetal brain in vivo has not been reported previously. The demonstration of 3D models may be helpful in the understanding of the complex area of fetal neurodevelopment. It provides additional diagnostic information to equivocal prenatal ultrasound (US) findings, which may be helpful in the management decisions made by the treating physician and the expecting parents.

Methods and materials: 11 patients underwent magnetic resonance (MR) imaging (17 examinations) for evaluation of the fetal brain. Indication for MR imaging was either an abnormal finding in the prenatal US examination or a relevant medical history (like a family history of lissencephaly), making specific assessment of the fetal brain necessary. The gestational age range was 19 to 37 weeks gestation. MR images were obtained on a 1.5 T GE system with SSFSE and standard sequences. After retrospective review of all the image series, 6 patients (11 examinations) were chosen for the segmentation and processing to 3D models. We chose one normal and a number of pathological cases. Not all images were suitable for 3D modelling due to gestational age of less than 20 weeks (1), multiple gestation (1), images not suitable for segmentation (3). After MR imaging was completed, the images were electronically transferred to a workstation (Sun Microsystems, Mountain View, CA). The following structures were manually segmented: skin, bone, cerebrospinal fluid, cerebral hemispheres, cerebellum, ventricles, eyes and pathological structures (eg. hemorrhage, encephalocele, vascular system) and surface models were generated (Fig 1). The final results were viewed on a workstation with graphics acceleration and 3D-slicer software allowing visualization and measurement of source images and models simultaneously. The 3D model can be rotated, enlarged and manipulated in real time by the viewer. The average time required to complete the image post processing is 3 hours, depending on each individual case.

Fig. 1: 3D-Model of the skin and brain of a fetus at 37 weeks gestation superimposed on the 2D SSFSE image.

Results: MR examination at 20, 24 and 28 weeks gestation positively excluded lissencephaly by demonstration of normal gyration in one case. In two cases, volume measurements could be obtained in a serial fashion demonstrating an improvement of the relevant fetal condition. The extent of hydrocephalus, as well as periventricular hemorrhage (Fig.2), diminished significantly between examinations and was quantifiable in the 3D models. Reconstruction of complex abnormalities like Dandy-Walker variant, and encephalocele combined with a large arachnoid cyst, made the understanding and demonstration of these lesions significantly easier. Reconstruction of the cerebral vascular system with a vein of Galen malformation and its feeding and draining vessels at 37 weeks gestation allowed the planning of the postnatal management by the interventional radiologist.

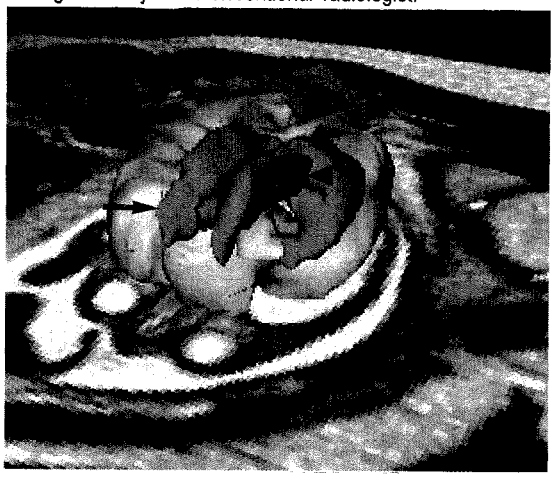

Fig. 2: Model of fetal brain demonstrating the ventricles (arrow) and periventricular hemorrhage (arrowhead) on the left at 28 weeks gestation. superimposed on the 2D SSFSE image.

Discussion: In displaying 3D models of a normal fetal brain and a variety of anomalies of the fetal brain in vivo, we have demonstrated some of the possible uses of this technique. 3D modelling makes the understanding of complicated configurations easier in comparison to the conventional way of imaging, using description and 2D images only. This technique may find clinical relevance, as greater morphological information and direct volume measurement of each structure (eg. brain, ventricles, hemorrhage) is more readily obtained. The use of these tools in a serial manner can provide necessary information about the progression of abnormal findings (eg. hydrocephalus) and therefore aid the management of each individual patient. In the future, 3D imaging may be used to aid prenatal counselling by facilitating the understanding of the abnormality by the expectant parents. Secondly, 3D imaging may be used in surgical simulation and treatment planning prior to the actual operative procedure, as this is already reality in the neurosurgical field. This may be especially relevant in the planning and performance of fetal surgical intervention for selected life threatening birth defects.

Conclusion: Rapidly improving computer hardware and software tools may soon make three-dimensional imaging faster and more cost-effective, and therefore more freely available. If this becomes a reality, such imaging could provide information that allows earlier and more accurate prenatal diagnosis, facilitating treatment planning for fetus and mother.