MEDICAL UNIVERSITY OF VIENNA

Superresolution MRI based brainstem visualization in vivo and in utero

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Objective

The fetal posterior fossa is a highly complex anatomic structure that includes many different functional systems. Even small substructures can be assessed with fetal MRI. This ongoing study aimed to retrospectively assess prenatal brainstem pathologies with reconstructed “superresolution” fetal MRI and postmortem data using biometry. The resulting insights aim to increase diagnostic accuracy and characterization of disorders in hindbrain segmentation.

Methods

Fetuses with brainstem malformations and an available fetal MRI, postmortem MRI and a confirmatory autopsy were included. Three orthogonal T2-weighted prenatal brain sequences were algorithmically reconstructed into a three-dimensional “superresolution” isovoxel dataset [1]. In this data, as well as in the isovoxel postmortem CISS sequence, volumes of the mesencephalon, pons, medulla oblongata and cerebellum were segmented with ITK-SNAP. Also, the area and diameters of these structures were quantified in both modalities.

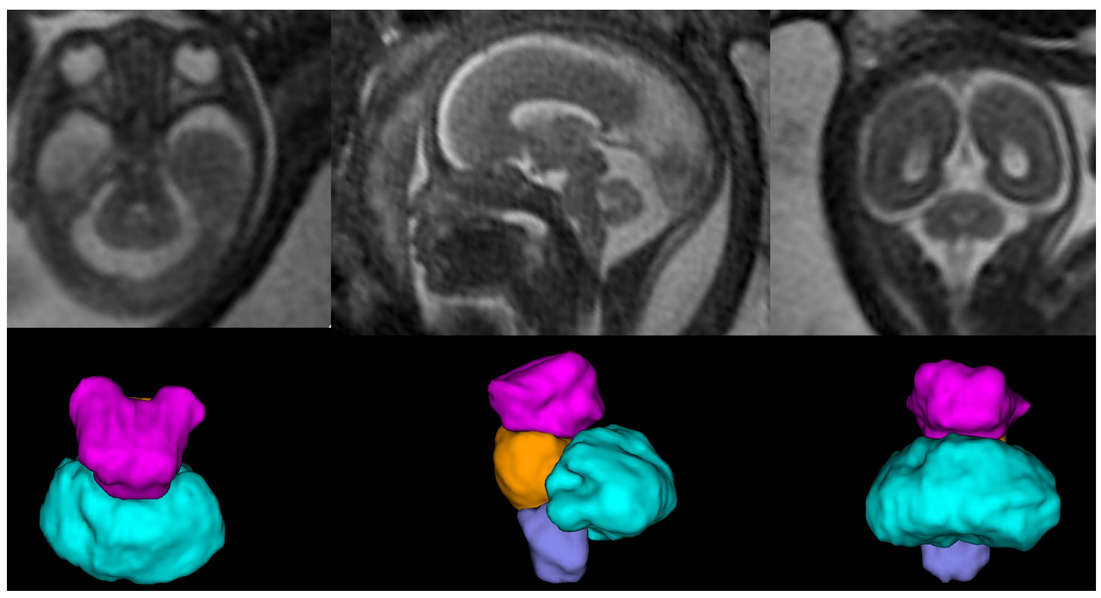


Figure 1 Fetal MRI (upper row) with a T2-weighted sequence in an axial (left), sagittal (middle), and coronal (right) plane. This fetus in gestational week 23+0 has a Rhombencephalosynapsis with generalized cerebellar hypoplasia, absent vermis, and fused cerebellar hemispheres. The segmented superresolution reconstruction (lower) visualize the prenatal anatomy of the midbrain (pink), pons (orange), medulla oblongata (purple) and cerebellum (light blue) well.

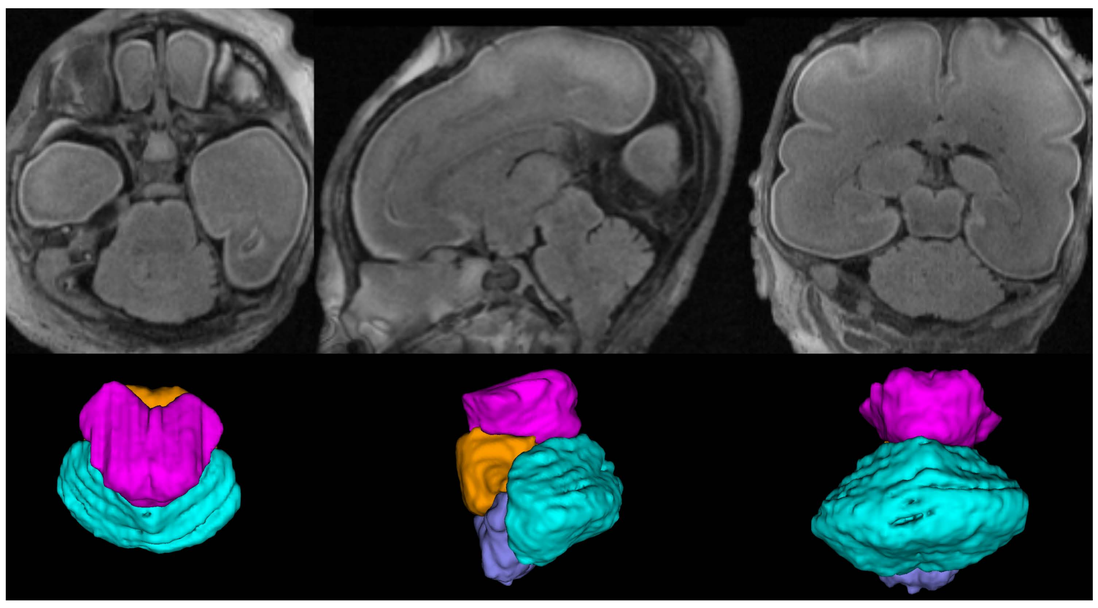


Figure 2 Postmortem MRI with an isovoxel CISS sequence (constructive interference in steady state) of the same fetus as in Figure 1 in gestational week 24+3. In the segmented three-dimensional reconstruction (same color scheme as in Figure 1) the fused cerebellar hemispheres and fissures (which are not interrupted by an absent vermis) can be seen excellently.

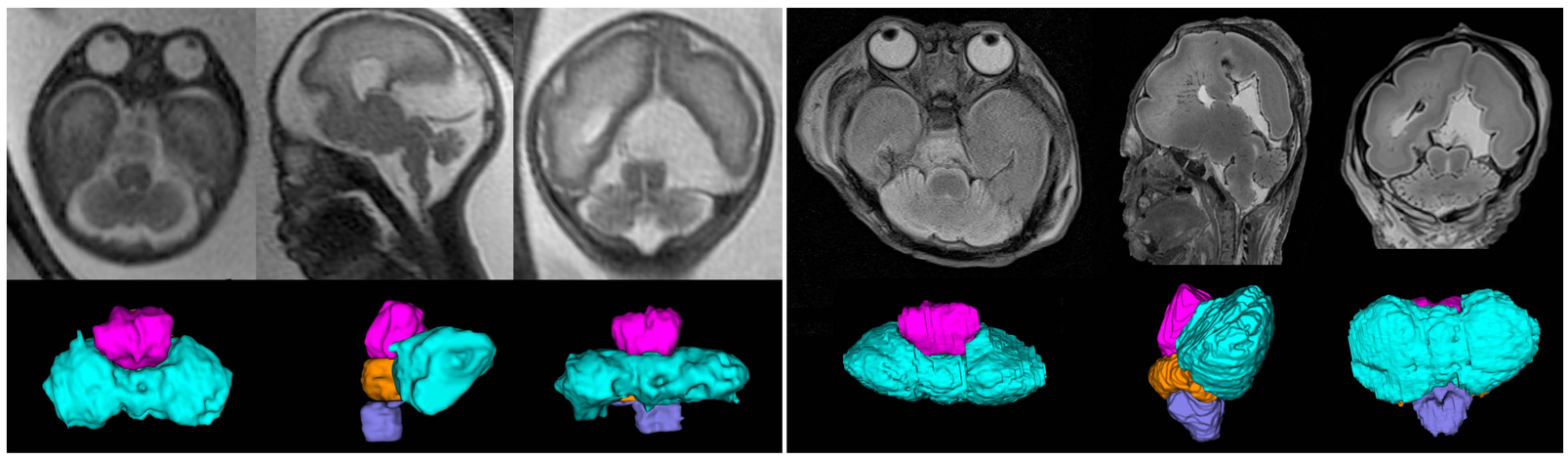
Results

In this retrospective study 29 fetuses were included with a mean age of 26.9±5.3 gestational weeks (range 18+3 to 37+5). Brainstem malformations included aqueductal stenosis, z-shaped brainstem, pontocerebellar hypoplasia, elongated and thin brainstem, disconnection between midbrain and pons, and dysplastic tectum. Among the associated cerebellar pathologies were cerebellar hypoplasia, rhombencephalosynapsis, and a dysplastic hypoplastic vermis [2-4]. All substructures of the fetal brainstem and cerebellum could be consistently measured in both modalities. The superresolution brainstem volumetry allowed for a more detailed assessment of brainstem disorders compared to standard two-dimensional evaluation.

Conclusion

Detailed prenatal three-dimensional analysis of posterior fossa structures is valid and possible prenatally using super-resolution reconstruction. Correlating prenatal superresolution MRI data with postnatal neurodevelopmental long-term outcomes using computerized image-based learning methods will optimize prenatal counseling of posterior fossa malformations. This will help to reduce anxiety of parents with ambiguous results during fetal organ screening examinations.

Figure 3 Comparison of a prenatal superresolution segmentation (left image; in gestational week 31+1) with the corresponding postmortem segmentation (right image; in gestational week 31+6) in a fetus with a complex syndrome including semilobar holoprosencephaly, arachnoid cyst, small pontine bulge and an altered medulla oblongata. Note the upward displaced vermis in both reconstructions.



References

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