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Quantification of Cerebellar Crowding in Type I Chiari Malformation

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Purpose

This study was focused on a semi-automated morphometric analysis of the cerebellum in the mid-sagittal plane as an alternative to tonsillar descent alone in the evaluation of Chiari malformation type 1 (CMI) patients.

Methods

Morphometric analyses of posterior fossa structures were performed on mid-sagittal MRI images of 375 individuals (females, > 18 years, 235 CMI and 140 healthy controls). Twenty-six parameters including linear, angular and area measurements together with non-dimensional ratios were calculated. A custom image analysis software, CerePro2D, was developed using MATLAB (MathWorks, Natick, MA) to measure those parameters semi-automatically.

Results

Eighteen parameters were found to be significantly different between CMI and control subjects:

- Smaller posterior cranial fossa (PCF) area in CMI subjects was attributed to a smaller PCF area anterior to the brainstem.
- The cerebellar area was found to be larger in CMI subjects as compared to controls (15.1%).
- This was true even without inclusion of the tonsillar area below the foramen magnum (FM) (8.4%).
- The larger cerebellar area in CMI subjects was due to cranial–caudal elongation of the cerebellum, predominately below the fastigium.
- The cerebrospinal fluid (CSF) spaces below the FM were smaller in CMI subjects as compared to controls.

Conclusions

For the first time, this study quantified morphometric measures of CMI crowding in the cranium near the cerebellum. These results indicate significantly greater crowding for CMI subjects as compared to controls. The present study showed that the mid-sagittal area of the CMI cerebellum was larger than that of controls even when the elongated tonsil below the FM was accounted for. The mid-sagittal MRI provides insight about morphological differences in CMI subjects compared to healthy controls. Neurosurgeons have, over the years, made surgical decisions based on a qualitative assessment of the crowding in the CMI brain. These results provide a quantitative understanding of how the crowding is altered in CMI.