

Can the Shape of the Cerebellum Help Identify Different Types of Chiari?

Chiari 1 is generally diagnosed based on how far the cerebellar tonsils extend below the opening at the base of the skull, known as the foramen magnum. However, researchers have long recognized that Chiari patients can have very different symptoms, anatomical characteristics, and responses to surgery. This raises an important question: Are all cases of Chiari 1 manifestations of the same underlying problem, or are there distinct subgroups that we have not yet learned to identify?

A new study from researchers at Massachusetts General Hospital and Harvard Medical School explored this question using a sophisticated MRI analysis technique to examine the overall shape of the cerebellum, rather than focusing on individual measurements such as tonsillar descent. The researchers analyzed high-resolution MRI scans from 186 adults with Chiari 1, including 152 women (82%) and 34 men (18%), with an average age of approximately 41 years.

The technique, called statistical shape analysis, uses computer software to compare the three-dimensional shape of a patient's cerebellum with a standard reference brain. By examining patterns of differences across the entire cerebellum, the researchers were able to group patients according to similarities in their anatomy. Importantly, the groups were identified by the computer analysis rather than being defined in advance by the researchers.

The analysis identified three distinct patterns of cerebellar shape. The largest group, Cluster A (84 patients), was characterized by increased fullness in the lower rear portion of the cerebellum and a flatter skull base, a characteristic known as platybasia. Cluster B (44 patients) showed a different pattern, with relative compression from front to back and changes in the upper portions of the cerebellum. Cluster C (58 patients) was characterized primarily by the downward displacement of the cerebellar tonsils, with fewer additional shape differences.

Interestingly, the three groups did not differ significantly in the amount of tonsillar descent, the frequency of syringomyelia, or the symptoms patients reported. The average tonsillar descent for the entire group was 8.3 mm. This suggests that patients who look similar according to traditional MRI measurements may have substantially different patterns of cerebellar anatomy.

The researchers also examined whether these anatomical differences were associated with surgical outcomes. Of the 186 patients, 59 had undergone posterior fossa decompression surgery, including 53 who had reported headaches before surgery. Patients classified as Cluster B were more likely to experience persistent or recurrent headaches following decompression. In a statistical analysis that accounted for differences in follow-up time, their rate of losing headache freedom was estimated to be six times that of patients in the other groups. However, this estimate was imprecise, and only 13 patients in Cluster B underwent surgery, making it difficult to draw firm conclusions about the relationship between cerebellar shape and surgical outcome. Unfortunately, the number of surgical patients was too small to meaningfully compare outcomes for symptoms other than headaches.

The broader significance of the research may be more important than the specific association with headaches. Previous studies have identified differences in posterior fossa size, skull shape, cerebellar volume, and other anatomical features among Chiari patients, but results have not always been consistent. One possible explanation is that different studies have included different mixtures of patients whose underlying anatomical problems are not identical. Statistical shape analysis offers a way to examine these differences more comprehensively and potentially identify meaningful subgroups without relying on a small number of predetermined measurements.

Whether these three subgroups will be confirmed by future studies remains uncertain. Nor does the study establish that different cerebellar shapes represent different causes of Chiari or require different surgical approaches. Nevertheless, the findings add to the growing evidence that Chiari 1 is not necessarily a uniform condition. With further development and validation, techniques such as statistical shape analysis may help researchers better understand the different

anatomical patterns found in Chiari patients and eventually determine whether identifying specific subgroups can improve diagnosis and treatment decisions.

Source: Nanda P, Kons ZA, Muñoz WJ, et al. Morphological subtypes of Chiari malformation type I and clinical outcomes after posterior fossa decompression. Journal of Neurosurgery. Published online October 9, 2026. doi:10.3171/2026.3.JNS241132.

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