Chiari Can Be Identified Anatomically 81% of the Time Without Tonsillar Position

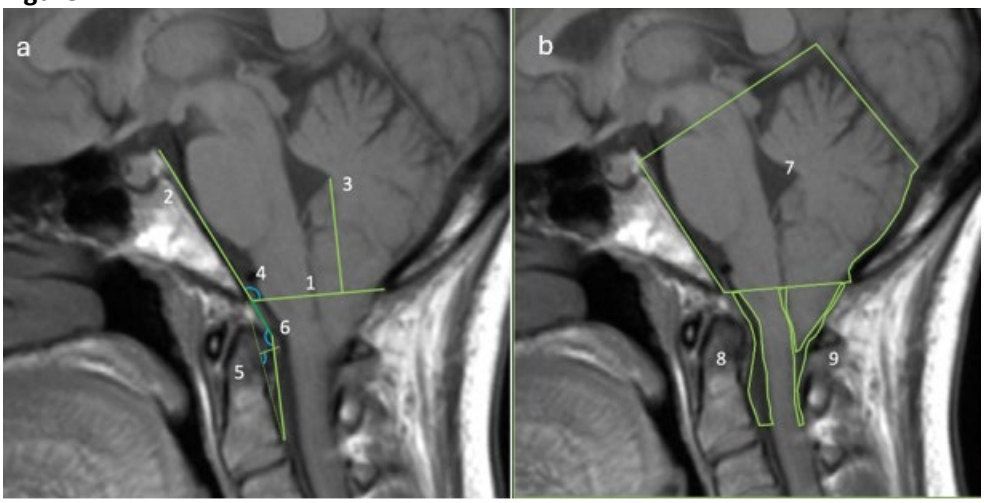
In recent years, morphometrics has been an active area of Chiari research. Morphometrics in terms of Chiari refers to using imaging such as MRIs or CTs to precisely measure distances and angles of anatomical features of the skull, brain, and spinal cord. Measurements are often compared between Chiari patients and healthy controls, between different Chiari subgroups, or are used to try to predict outcomes.

This type of research has clearly demonstrated that on average there are significant differences between Chiari patients and non-Chiari controls. In general, these differences can be grouped as reduced height of posterior cranial fossa (PCF) structures/PCF area; a wider foramen magnum (longer McRae line); a short and/or mis-angled clivus bone; reduced cerebrospinal fluid (CSF) spaces below the foramen magnum; and upward migration and/or retroflexion of the odontoid. However, in absolute terms these differences are often small and their contribution to symptomatic Chiari is not clear. It is also not clear how common they are in the overall Chiari population.

Using images from the Chiari1000, Conquer Chiari researchers have shown that significant variations in these anatomical measurements are common in Chiari patients. They are so common in fact that Chiari can be correctly identified 81% of the time without even looking at the cerebellar tonsils. For the study, the researchers compared 9 morphometric measurements (see Figure 1) from the MRIs of 432 adult female patients to 148 age matched healthy females from the Human Connectome Project (a publicly funded research project which makes their imaging and data available for research).

As has been seen in previous research, comparing the average measurements between Chiari and controls showed significant differences for all nine measures. However, the researchers then looked at the distribution of Chiari patients by determining what percentage of patient measurements were at increasing distances from the control average (this was based on a statistical measure called standard deviation). They found that fastigium height (#3 in Fig 1) had the highest percentages away from the control average and Grabb-Oakes (#5) had the lowest percentages. Specifically, 80% of the Chiari patients' fastigium height was at least .5 standard deviations from the control mean, 64% were at least 1 full standard deviation away, and nearly half (46%) were at least 1.5 standard deviations shorter than the control average.

Figure 1



1) McRae line length (ML) 2) clivus bone length (CL) 3) fastigium height (FH) 4) Boogard angle (BA) 5) Grabb-Oakes distance (GO) 6) clivo-axial angle (CXA) 7) posterior cranial fossa area (PCFA) 8) anterior cerebrospinal fluid area (ACSF) 9) posterior cerebrospinal fluid area (PCSF)

Using a different statistical technique they then translated these into the odds of having Chiari and found that participants with a fastigium height of less than 26mm were 13 times as likely to have Chiari than participants

with a fastigium height greater than 26mm. It is not known of Chiari patients are born this way or if the lower half of the cerebellum is being pulled down due to the difference in pressure between the brain and spinal regions caused by the cerebellar tonsil blockage.

A second interesting finding was that the amount of anterior CSF space (in front of the spinal cord) was more predictive of having Chiari than the posterior CSF space which is around the herniated tonsils. This supports a different Conquer Chiari study which found that adult women with smaller anterior CSF spaces had worse outcomes after surgery.

But these weren't the only two measures of interest. On average, the Chiari patients had at least 3 of the 9 measures land at least 1 standard deviation from the control average. In contrast, the participants from the Human Connectome Project on average only had 1 such anatomical measurement. In fact, the researchers were able to build a statistical model using just six of the measures which correctly identified Chiari versus control 81% of the time. It should be stressed that the purpose of this was not to create a new diagnostic, but rather to determine how common these types of anatomical variations are in Chiari patients.

Finally, the researchers grouped the participants by how severe their anatomical variations were and compared the groups across different clinical measures including but not limited to surgical rate, syringomyelia, neck disability, depression, and cognitive performance. Perhaps surprisingly, they found no difference in any of the measures between the groups. This seems to indicate that while anatomical variations beyond tonsillar position are quite common with Chiari and significantly increase the likelihood of having Chiari, they are not related to the severity of Chiari symptoms.

Note: Rick Labuda, the Executive Director of Conquer Chiari, contributed to this research as Principal Investigator and is the author of this research update.

The full publication is available for free at: https://www.nature.com/articles/s41598-026-36412-6

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