

### Key Points

1. Research has shown that the amount of tonsillar herniation is not related to symptoms or clinical outcome
2. Some researchers have looked at CSF flow and velocity as clinical indicators with mixed results
3. Study used advanced imaging techniques to quantify several parameters before and after surgery in 12 Chiari patients
4. 11 patients improved after surgery, 1 had persistent symptoms
5. CSF velocity and flow did not change significantly after surgery
6. On average, intracranial compliance did increase significantly after surgery
7. Compliance increased in 10 of the 12 patients; the one patient who had lower compliance after surgery was the one with persistent symptoms
8. More research is needed - with more subjects - but compliance could turn out to be a single objective test of both symptomatic Chiari and a way to compare surgical techniques and outcomes

### Definitions

**cerebellar tonsils** - portion of the cerebellum located at the bottom, so named because of their shape

**cerebrospinal fluid (CSF)** - clear liquid in the brain and spinal cord, acts as a shock absorber

**Chiari malformation** - condition where the cerebellar tonsils are displaced out of the skull area into the spinal area, causing compression of brain tissue and disruption of CSF flow

**cine MRI** - type of MRI which can measure CSF flow

**compliance** - a measure of how much a vessel changes in volume due to a change in pressure;

## Intracranial Compliance Linked To Surgical Success

*[Ed. Note: In the spirit of full disclosure, Dr. Terry Lichtor, one of the authors of this study, is a Scientific Advisor to this publication. In addition, the Editor's family was directly responsible for sponsoring this work.]*

Chiari has traditionally been defined as the cerebellar tonsils descending out of the skull (or herniating) at least 3mm-5mm. Numerous research has shown however that the amount of herniation is not related to the presence and severity of symptoms, nor to clinical outcomes. Some people have large herniations with virtually no symptoms, while others have very small herniations with severe symptoms.

This disparity has caused problems for many patients over the years. Someone with 2mm of herniation, but crippling headaches, may be told the headaches are due to something else, delaying an accurate diagnosis.

Because there is no single, objective test to say whether a Chiari Malformation is symptomatic, doctors must rely on their judgment and experience. This can pose problems after surgery as well. Without an objective measure of success, how do you determine if symptoms that appear - or come back - years after surgery are due to the Chiari?

With the introduction of cine MRI, and its ability to show the flow of cerebrospinal fluid which occurs naturally with each heartbeat, some doctors and researchers have focused on CSF flow as a measure that can be used both before and after surgery. While some are strong advocates of cine MRI, others have questioned its usefulness.

There is little doubt that a Chiari malformation disrupts CSF flow in some way, however the research is mixed on whether this can be used as an objective measure. In fact, research has shown that the results of CSF flow tests vary greatly depending on where it is measured - behind the cerebellar tonsils or at C2, for example. To make matters worse, CSF flow measurements are very dependent on a number of variables, such as neck position, which makes consistent measurements difficult.

Now, a group of researchers out of Chicago has used advanced imaging techniques to show that a parameter known as compliance may be a useful measure of surgical outcome in Chiari patients. Anusha Sivaramakrishnan, Dr. Noam Alperin, and Sushma Surapaneni from the University of Illinois, Chicago, along with Dr. Terry Lichtor, a neurosurgeon at Rush-Presbyterian Medical Center, examined the effects of decompression surgery on a number of MRI derived parameters - including compliance - in 12 Chiari patients. The team published their results in the December issue of the journal, *Neurosurgery*.

The Chiari patients included 8 women and 4 men with herniations ranging from 5mm -17mm. Four had Chiari only, 5 had Chiari plus syringomyelia, and 3 had Chiari plus hydrocephalus. Each patient underwent a similar surgery which included a sub-occipital craniectomy, laminectomy, and duraplasty. Eleven of the twelve patients improved symptomatically after surgery, while one person continued to suffer from symptoms.

Using cine MRI, the research team measured - both before and after surgery - the amount of spinal cord displacement, the maximum CSF velocity, maximum CSF flow rate (how quickly a volume of CSF moves), the amount of CSF which flowed back and forth between the skull and spine, and the intracranial compliance.

As discussed in [Compliance May Be Key To SM & Alzheimer's](#), compliance is a measure of a vessel's, or container's, stiffness. It is measured as the change in volume of a vessel in response to a change in pressure. A highly compliant container, like a balloon, can be expanded by blowing air into it. A low compliance container, like a glass jar, will not expand much as the pressure inside it is increased.

Recall that with every heartbeat, blood rushes into the brain/cranium via arteries, blood flows out through veins, and CSF flows from the skull to the spinal area. Thus, intracranial compliance is a measure of how the cranium/brain area responds to the inrush of blood during a heartbeat. To measure compliance, the research team quantified the total amount of blood and CSF flowing into and out of the skull area during a heartbeat, quantified the pressure of the CSF, and then mathematically derived a Compliance Index for each subject.

Of all the parameters measured, the team found that only the Compliance Index significantly changed on average after surgery (see Table 1). It increased an average of 64 % for the group and increased in 10 of the 12 patients. In one person, it remained unchanged, and it actually decreased in one person. Interestingly, the person in whom compliance decreased after surgery was the person who continued to suffer from symptoms after surgery. During surgery, this patient was noted to have a significant amount of dural scarring and adhesions, which may explain why the operation did not work.

dV/dP; the inverse of elastance

**cranium** - the skull

**craniectomy** - surgical technique where part of the skull is removed

**dura** - tough, outer covering of the brain and spinal cord

**duraplasty** - surgical technique where the dura is opened and expanded by sewing a patch into it

**hydrocephalus** - a condition where there is an unusually large amount of CSF in the brain, resulting in swollen ventricles

**intradural exploration** - general term referred to a surgeon finding and removing any scarring or obstructions to CSF flow that exist underneath the dura

**laminectomy** - surgical technique where part of a vertebra is removed

**posterior fossa** - depression on the inside of the back of the skull, near the base, where the cerebellum is normally situated

**syringomyelia (SM)** - neurological condition where a fluid filled cyst forms in the spinal cord

**tonsillar herniation** - descent of the cerebellar tonsils into the spinal area; often measure in mm

**ventricle** - a CSF filled space in the brain

While the compliance finding is the most significant, it is also noteworthy that this study did not find that simply measuring CSF velocity was a useful parameter. This is in contrast to some research and the authors of this study point out that they measured CSF over a wider area and that previous studies showed changes in velocity at specific points.

Clearly, more research is required to establish the link between compliance and clinical symptoms and outcomes, but this study does offer promise that a single, objective test to evaluate Chiari and the effects of surgery may be possible. In comments published in the same journal, Dr. Mark Hadley said, "This type of assessment has broad application for patients with increased intracranial pressure and reduced intracranial compliance from any cause."

**Table 1**  
**Selected MRI Derived Parameters (Average For 12 Patients)**

Measurement	Before Surgery	After Surgery
Max Spinal Cord Displacement (mm)	.32	.25
Max CSF Velocity (cm/s)	1.6	1.56
Max CSF Volumetric Flow Rate (ml/min)	180.5	153.5
Compliance Index	6.9	11.3

**Note:** Only Compliance demonstrated a statistically significant change from before to after surgery

**Related C&S News Articles:**

[Compliance May Be Key To SM & Alzheimer's](#)

[The Importance Of Cine MRI](#)

[Decompression Surgery Reduces CSF Velocity.](#)

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**Source**

Sivaramakrishnan A, Alperin N, Surapaneni S, Lichtor T. [Evaluating the effect of decompression surgery on cerebrospinal fluid flow and intracranial compliance in patients with Chiari malformation with magnetic resonance imaging flow studies.](#) Neurosurgery. 2004 Dec;55(6):1344-51.

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