Effect of Scan Type, Timespan, and BMI on Chiari I Malformation Tonsil Ectopia Length

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Disclosure Slide

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Introduction

A Chiari I malformation (CMI) is defined radiologically as cerebellar tonsillar descent 5 or more mm below the foramen magnum\(^1\). The ectopia seems to inhibit the flow of cerebral spinal fluid (CSF) between the cranial and spinal compartment\(^2,3\). This is associated with a variety of symptomatology, including headaches, fatigue, hyperacusis, dysphagia, sleep apnea, ataxia, visual disturbances, dysarthria, tinnitus, and vertigo\(^4,2\).

The simple measurement of cerebellar ectopia may seem straightforward, but there are several outstanding questions. The first is “Does it matter whether the measurement is determined on a cranial or cervical spine MRI?” This is important because the image slice thickness of the cranial MRIs from our and regional MRI centers are usually 5mm and the cervical spine MRIs are typically 3mm, and this could affect measurements of Chiari malformation.

Furthermore, previous studies on the evolution of CMIs have been inconclusive. This brings forth the question “Is the amount of ectopia fixed over time in adults or is it dynamic?” This addresses the problem of whether the exam needs to be repeated if it has been months or years since the previous exam.

Lastly, prior studies have found a positive association between increased BMI and the pathogenesis of CMI and syringomyelia in adults with symptomatic deterioration\(^5,6\). This leads to the third, and final question “Does BMI effect the degree of tonsil ectopia?”
Methods

This study selected CMI subjects from a population of 161 patients of a single neurosurgeon from 2006 to 2019. Most exams were obtained from a 1.5T at the parent institution. Measurements of cerebellar tonsil position on cranial and spinal MRIs were obtained on spin echo (SE) T1-weighted sagittal images. The measurement method is depicted in Figure 1. All measurements were done in the imaging system, documented in spreadsheets, and analyzed in R.

In Part 1, the measured ectopia length from each patient’s cranial and spinal MRI were compared in R using the boxplot function. A paired t.test, with unequal variances was then performed.

In Part 2, the time between scans was measured in two different ways: long time between scans and short time between scans. In the case of short time between scans, the time and changes in ectopia length between neighboring scans were calculated. In the case of the long time between scans, the changes in ectopia length between the first and subsequent scans were calculated. The values for each patient were then averaged for the second set of tables. All tibbles were then analyzed using the cor.test function in R.

In Part 3, the changes in BMI between scans was measured, averaged, and analyzed in the same two ways as was done in Part 2 except the change in BMI was used. These data were also analyzed using the geom_point function.

Figure 1 | How to measure a tonsil ectopia.
1) Draw a line from the basion (B) to the opisthion (O). 2) Draw a line perpendicular to the basion-opisthion line and extended inferiorly to the most inferior position of the cerebellar tonsils (C).
Part 1 Results

- There were 81 patients (66 female, 15 male)
- Ages ranged from 16 – 73 (mean: 38 years)
- The average ectopia length on a cranial MRI was 9.1mm (±5.2mm), while the average ectopia length on a spinal MRI was 8.9mm (±5.3mm). This is seen in Figure 2.
- The range of ectopia lengths were 3.1-30.1mm (Cranial) and 2.9-30.0mm (Spinal).
- The mean of differences was 0.6999197.
- The t-test (two-tailed, non-equal variances) performed revealed that $t_{stat.} = 0.79494$, while $t_{crit.} = 1.9901$. Since $t_{stat.} < t_{crit.}$ the differences are likely due to chance
- This t-test gave a p-value of 0.429, meaning any differences are not statistically significant.
- Parts 2 and 3 of the study were initiated after the results of Part 1 were known, allowing the use of either a cranial or spinal exam.
Part 2 Results

- There were 111 patients (96 female, 15 male)
- Age range of 15-75 (mean: 38) years
- Repeated means that there were multiple values for each patient
- The average short-time between scans was 438.75 days, while the average long-time between scans was 933.57 days.
- The results of the four statistical tests are in Table 1
- Three out of the four tibbles had high enough correlation coefficients and low enough p-values to show that there is a small/weak correlation between the time between scans and change in ectopia length.

<table>
<thead>
<tr>
<th>Tibble</th>
<th>Correlation Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RL</td>
<td>0.2708162</td>
<td>5.976e-05</td>
</tr>
<tr>
<td>RS</td>
<td>0.1805275</td>
<td>0.008116</td>
</tr>
<tr>
<td>AL</td>
<td>0.2954778</td>
<td>0.001642</td>
</tr>
<tr>
<td>AS</td>
<td>0.1723673</td>
<td>0.07045</td>
</tr>
</tbody>
</table>

Table 1| Results of Pearson-correlation tests. RL: Repeated long-time between scans; RS: Repeated short-time between scans; AL: Averaged long-time between scans; AS: Averaged short-time between scans.
Part 3 Results

• Total of 71 patients (66 female, 11 male)
• Age range of 15-75 (mean: 40) years
• The values that went into calculating the BMI had to be obtained within a month of the MRI.
• Repeated means that there were multiple values for each patient
• Even though a few of the correlation coefficients were greater than 0.1, the p-values were too large for the effect of change in BMI on tonsil ectopia length to be statistically significant (Table 2).
• The averaged long changes with BMI tibble was made into a figure (Figure 3) to further illustrate the lack of correlation.

<table>
<thead>
<tr>
<th>Tibble</th>
<th>Correlation Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS</td>
<td>0.006391815</td>
<td>0.9422</td>
</tr>
<tr>
<td>RL</td>
<td>0.1077668</td>
<td>0.2205</td>
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<tr>
<td>AS</td>
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<tr>
<td>AL</td>
<td>0.1722603</td>
<td>0.1509</td>
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</tbody>
</table>

Table 2: Results of Pearson-correlation tests. RS: Repeated short calculated changes with BMI; Repeated long calculated changes with BMI; AS: Averaged short calculated changes with BMI; AL: Averaged long calculated changes with BMI.

Figure 3: Scatterplot of the effect of average long time change in BMI on change in ectopia length.
Discussion

Our hypothesis that cervical spine MRIs would be necessary to accurately measure ectopia length was rejected by these data. Even though a spinal MRI provides greater spatial resolution than the cranial MRI, it is not needed to accurately measure tonsillar ectopia length. This result agrees with a similar study that concluded that the selection of slice thickness was not significant for the classification accuracy when analyzing well-defined regions of interest\(^7\). The hypothesis that tonsil ectopia length would change over some time was weakly statistically supported by these data. Relatively recent MRIs are more useful to physicians when determining whether or not patients should have decompression surgery. To our knowledge this specific issue has not been previously studied. Our hypothesis that tonsil ectopia length will change with fluctuations in BMI was rejected by these data. The multiple Pearson Correlation tests performed showed that there was no statistically significant correlation between changes in BMI and ectopia length. This agrees with the results of a previous study\(^8\). The results of our experiment were not aided by the fact that there were very few large fluctuations in BMI.
Summary Points

• Study 1 showed that spinal MRIs were almost identical to those from the cranial MRIs.

• Study 2 showed that time was a factor in changes cerebellar tonsil ectopia length.

• Study 3 showed that BMI and changes in BMI do not correlate with changes in ectopia length.
Bibliography


