Eye Tracking to Diagnose Oculomotor Abnormalities in Patients With Chiari Malformation

Molly E. Hubbard MD; Julia Schneider BS; ByoungJun Han; David H. Harter MD, FACS, FAAP, FAANS; Howard L. Weiner MD; Jeffrey H. Wisoff MD; Uzma Samadani MD
Hennepin County Medical Center, Minneapolis, MN
NYU School of Medicine, New York, NY

CNS 2016 ANNUAL MEETING San Diego CALIFORNIA SEPTEMBER 24-28, 2016

Hennepin County Medical Center

Learning Objectives

1.To assess oculomotor abnormalities as a result of chiari malformation
2.To use a non-invasive diagnostic tool to help with assesing symptomatology from chiari malformation
3.To see if the effect of decompression surgery for chiari malformation impacts eye tracking metrics

Introduction

The cerebellum is essential for coordinating eye movements and keeping both eyes fixed on a single target. In some congenital conditions, such as with Chiari Malformations, the cerebellar tonsils (Chiari I) or vermis and brainstem (Chiari II) are displaced inferiorly through the foramen magnum. This translocation of the hindbrain tissue can lead to abnormalities in lower cranial nerve and cerebellar function. There are varying degrees of dysfunction in both types, and some of this dysfunction may be subclinical. Here we report our findings after eye tracking of subjects before and after Chiari decompression, as well as controls.

	Pre-op	Pre op Control	Post-op	Post op Control
N (#)	21	84	28	28
Gender	12 F 9 M	51 F 33 M	15 F 13 M	15 F 13 M
Mean age	19.2	19.7	16.0	16.2

Methods

There were 21 patients evaluated prior to decompression (mean age 16.0, 12 females and 9 males) and 28 post-operative patients (mean age 19.2, 15 females, 13 males). All patients who had undergone surgery were symptomatic preoperatively. Eye-tracking metrics were measured using a non-spatially calibrated Eyelink 1000 eye tracker. Each subject was recorded at a fixed distance of 55 cm from a computer monitor at a duration of 220 seconds while following a video moving clockwise along the outer edges of the monitor. Eye tracking metrics were evaluated in patients with Chiari malformations that had not yet been operated (pre-operative group) and in post-decompression patients (post-operative group); and then each group was compared to age and gender matched normal healthy controls. In both cases, p values were adjusted using Bonferroni and False Discovery Rate (FDR) methods.

Results

Patients who have undergone Chiari decompression were found to have 8 eye tracking metrics which were significantly different from age and gender matched controls. Patients who had undergone decompression showed no significant difference when compared to an age and gender matched control cohort. Model selection in the table below indicates the effect terms being evaluated.

Chiari Pre-op (Group=5,n=21) vs Control (Group=9,n=84)					
	Model Selection		F-test p-value		
Dependent	Outcome=Age + Gender+	FValue	Raw	Bonferroni	FDR
Binocular box-score value	Group+Group*Gender	6.08	0.0032	0.2867	0.0413
Horizontal Binocular Variance (right side of screen)	Group+Group*Age	5.84	0.0040	0.3555	0.0444
Height/width of area traveled by left eye (aspect ratio)	Group+Group*Gender	6.29	0.0027	0.2392	0.0413
Left eye: blink length value	Group+Group*Age+Group*Gender	5.17	0.0023	0.2061	0.0413
Right eye: blink length value	Group+Group*Age+Group*Gender	5.17	0.0023	0.2061	0.0413
Right eye: distance traveled along lower screen	Group+Group*Gender	6.17	0.0030	0.2661	0.0413
Right eye: distance traveled along upper screen	Group+Group*Age	6.07	0.0033	0.2891	0.0413
Right eye total variance	Group+Group*Gender	10.66	0.0001	0.0057	0.0057

Conclusions

Patients who are status post Chiari decompression have eye tracking metrics which are more similar to healthy controls without Chiari malformations, while patients who have not undergone Chiari decompression are different from age and gender matched healthy controls. This suggests that eye tracking has the potential to provide a non-invasive and quantitative measure of ocular motility dysfunction in Chiari Malformation. This could be beneficial in patients where it is not clear if the Chiari is symptomatic or not; as eye tracking could potentially provide an objective measure of dysfunction. While patients with asymptomatic Chiari malformations were not assessed in this study, future plans to evaluate that group of patients will hopefully validate eye tracking as a valuable tool for diagnosis.

References

1. Samadani, U. et al. Detection of third and sixth cranial nerve palsies with a novel method for eye tracking while watching a short film clip. Journal of neurosurgery, 1-14, doi:10.3171/2014.10.jns14762 (2014).

2. Beh, S. C., Frohman, T. C. & Frohman, E. M. Neuro-ophthalmic Manifestations of Cerebellar Disease. Neurologic Clinics 32, 1009-1080, doi:http://dx.doi.org/10.1016/j.ncl.2014.07.002 (2014).

3. Salman, M. S., Sharpe, J. A., Lillakas, L., Dennis, M. & Steinbach, M. J. Visual Fixation in Chiari Type II Malformation. Journal of child neurology 24, 161-165, doi:10.1177/0883073808322326 (2009).

4. Kobayashi, M. & Sugiyama, A. Decreased ratio of downward to horizontal smooth pursuit eye movement velocity in a patient with Chiari I malformation: application in early detection of vestibulocerebellar malfunction. Internal medicine (Tokyo, Japan) 51, 2025-2029 (2012).