ARTICLE

High Prevalence of Visual Midline Shift Syndrome in TBI: A Retrospective Study

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ABSTRACT

Background: Visual Midline Shift Syndrome (VMSS) is a common finding in patients who have suffered traumatic brain injury (TBI) and stroke. Proper identification of VMSS will allow for best patient management since VMSS has previously been shown to be treatable with Yoked Prism lenses. The purpose of this study was to determine the prevalence of VMSS in a group of patients with TBI compared to patients with no report of TBI.

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Keywords: Abnormal Egocentric Localization (AEL), Traumatic Brain Injury (TBI), Visual Midline Shift Syndrome (VMSS)

Methods: A single-center retrospective study of 60 patients (30 TBI and 30 non-TBI) was conducted by chart review to determine the prevalence and direction of VMSS in each group. The presence of VMSS was determined by Visual Midline Shift Testing where the patient was instructed to follow a moving Wolff Wand fixation target performed at 3 gazes horizontally from both directions to detect any right or left VMSS and then the procedure was repeated vertically to detect any anterior or posterior VMSS.

Results: A much higher prevalence of VMSS was found in the TBI group (93%) compared to the non-TBI group (13%). This difference was found to be statistically significant by Chi-Square analysis (p-value of <0.0011). The directions of VMSS in the TBI group, in order of prevalence were right (82%), anterior (64%), posterior (11%), and left (7%). Chi-Square Goodness-of-Fit Test showed the prevalence of right VMSS is statistically different than left VMSS or no right/left VMSS. (p-value < 0.001) and anterior VMSS is statistically different than posterior VMSS or no anterior/posterior VMSS (p-value = 0.002).

Conclusion: The prevalence of VMSS is extremely high in patients with TBI. Our study also found a much higher prevalence of right or anterior VMSS. Our data supported VMSS testing to be performed on all patients with a history of TBI.

INTRODUCTION

Visual Midline Shift Syndrome (VMSS) was first described in the scientific literature by Padula in 1996 as "an unusual phenomenon that often occurs following a neurological event, such as a hemiparesis or hemiplegia, that the ambient visual process changes its orientation to concept of midline." It was tested "whereby a wand is passed before the person laterally and the person is asked to state when the wand appears to be directly in front of the person's nose … This shift in concept of midline also can occur in an anterior posterior axis, causing the individual to experience a midline shift anteriorly or posteriorly."[1] This phenomenon was also described in the literature as "Abnormal Egocentric Localization" by other authors.[2] VMSS was found in 40% of the 60 Acquired Brain Injury patients which included both Traumatic Brain Injury (TBI) and Cerebral Vascular Accident (CVA) in a retrospective study conducted in an institutional setting by Bansal et.al.[2] Further research by Padula et. al. found VMSS in over 70% of patients with CVA.[3] However, neither study had a control group to determine if VMSS occurs in individuals with no history of TBI or CVA. Further, the prevalence of VMSS in non-TBI patients has not been reported in the literature.

In a recent study, Padula et. al. utilized a computerized walkway mat and demonstrated objectively that VMSS causes imbalance when walking.[4] Proper identification of VMSS will therefore allow for best patient management since VMSS was shown to be treatable with yoked prisms lenses.[2,3,4] The purpose of our study was to determine the prevalence of VMSS in a group of patients with TBI compared to patients with no report of TBI.

METHODS

A retrospective study was conducted by chart review of all new TBI patients who received a Neuro-Optometric Examination from January 2014 to October 2015 at the Center for Vision Development Optometry, a referral-based private optometric practice in Pasadena, California. The Neuro-Optometric Examination performed at our practice includes a primary care eye examination, binocular evaluation, and evaluation of VMSS, gait, posture, and balance. Another 30 consecutive charts were reviewed for patients with no known history of TBI who presented for an optometric examination (new patients presenting for an initial examination or existing patients receiving an annual examination) from July to October 2015. The goal was to have a sample size of approximately 30 patients in each group.

The data collected for the TBI patients included patient demographics (age, gender, refractive status), cause of TBI (fall, motor vehicle accident, struck by/against, assault, others), referral source: physicians/psychologist (e.g. MD, OD, etc), rehabilitation professional (e.g. occupational therapist, physical therapist, speech-language pathologist, etc.), family/friend, self-referred (e.g. Internet search) and the presence and direction of VMSS (Anterior, Posterior, Right, Left, None). Inclusion criteria for the TBI group were history of traumatic brain injury, concussion, head trauma, and/or motor vehicle accident. Exclusion criteria were non-TBI brain injuries (e.g. Stroke, Brain Tumor, etc), autism spectrum disorder, wheel chair-bound, lack of alertness or cognitive abilities to understand the instruction and to provide a verbal response to the Visual Midline Shift Test.

The data collected for the non-TBI patients included patient demographics (age and gender) and the presence and direction of VMSS. Inclusion criteria for the non-TBI group were no history of traumatic brain injury, concussion, head trauma, and/or motor vehicle accident. Exclusion criteria were history of TBI (reported prior to or during the course of the examination), other brain injuries (e.g. Stroke, Brain Tumor, etc), autism spectrum disorder, lack of alertness or cognitive abilities to understand the instruction and to provide a verbal response to the Visual Midline Shift Test. Strabismus was not chosen as exclusion criteria for either group since it is a common finding in the general patient population of this private practice as well as TBI patients. The retrospective study conducted by Ciuffreda et.al.[5] found strabismus in 41 out of 160 TBI patients (25.6%). In our study, there were 5 subjects (16.7%) with strabismus in the TBI group (4 constant esotropes and 1 intermittent exotrope) and 4 subjects with strabismus (13.3%) in the non-TBI group (2 constant esotropes and 2 constant exotropes).

Refractive error and best corrected visual acuities were not used as exclusion criteria due to the gross nature of the visual task in testing for visual midline shift. The Wolff Wand fixation target ball which is about half-inch wide is expected to have a visual angle of 109 minutes of arc (1.82 degrees) at a viewing distance of 16 inches based on the trigonometry formula: tan θ = 0.5 inches / 16 inches. This target size is more than 100 times the angle of subtense of a 20/20 Snellen Optotype which has an angle of subtense of 1 minute of arc (0.0167 degrees) at 20 feet. Therefore, uncorrected refractive error and reduced visual acuities are not likely factors that will affect VMSS testing unless the visual acuities are worse than 20/1000. The subjects in our study who have significant refractive error were instructed to wear their habitual spectacles or contact lenses for VMSS testing.

Figure 1: Testing of Horizontal VMSS

Testing of VMSS

The criterion of diagnosing VMSS is based on the patient's subjective perception of his/her visual midline relative to physiological midline. VMSS testing was performed with the patient standing with the head and body straight. The examiner stands in front and off to the right side of the patient (so that the patient will not use the examiner's face and nose as a point of reference for midline). The target used was a Wolff Wand fixation target[a] (a silver-colored spherical metallic target ball approximately half an inch in diameter mounted on a metallic wand) that was held about 16 inches away from the patient's face and moved at a speed of approximately 5 inches per second. The patient was instructed to follow the horizontally-moving target with his/her eyes without moving his/her head and inform the examiner when the target appears to be directly in front of their nose or in the middle (Fig. 1). It was first performed to obtain the horizontal midline point in primary gaze (while following the moving target at eye level from left to right and viewing at eye level). It was then performed to obtain the horizontal midline point in down gaze (while following the moving target from left to right and viewing approximately 45 degrees below eye level). Finally, this was performed to obtain the horizontal midline point in up gaze (while following the moving target from left to right and viewing approximately 45 degrees above eye level).

The rationale of testing three gazes is based on the concept that an imaginary straight line can be drawn with three data points. The test was repeated at primary gaze, down gaze, and up gaze from the other direction (e.g. right to left). The reason for repeating the test in the other direction is to ensure consistency of the response (i.e. VMSS is not due to the patient's slow verbal response). If the patient gave inconsistent response, the results would be considered inconclusive for the presence of a horizontal VMSS.

Figure 2: Testing of Vertical VMSS

The second part of the testing was performed where the examiner positions himself/herself below the patient's eye level (so that the patient will not use the examiner's face and nose as a point of reference for eye level). The patient was instructed to follow a vertically moving target without moving his/her head and report when it reached eye level (Fig. 2). It was first performed to obtain the vertical midline point in primary gaze (while following the moving target along the vertical midline from superiorly to inferiorly). It was then performed to obtain the vertical midline point in right gaze (while following the moving target from superiorly to inferiorly and viewing approximately 45 degrees to the right). Finally, this was performed to obtain the vertical midline point in left gaze (while following the moving target from superiorly to inferiorly and viewing approximately 45 degrees to the left). The test was then repeated at the primary gaze, left gaze, and right gaze from the other direction (e.g. from inferiorly to superiorly). If the patient gave inconsistent response, the results would be considered inconclusive for the presence of a vertical VMSS. The total time needed to perform both horizontal and vertical VMSS testing for each patient is approximately 1 to 2 minutes.

A right visual midline shift was considered present when the patient reported that the target was lined up with their nose when it was actually off-centered to the right of their nose by approximately half an inch or more (i.e. the width of one Wolff Wand fixation target ball). A left visual midline shift was considered present when the patient reported that the target was lined up with their nose when the target was off-centered to the left of the patient's nose by approximately half an inch or more. An anterior visual midline shift was considered present when the patient reported that the target was at eye level but it is actually below eye level by approximately half an inch or more. A posterior visual midline shift was considered present when the patient perceived the target to be at eye level when it was actually above eye level by approximately half an inch or more.

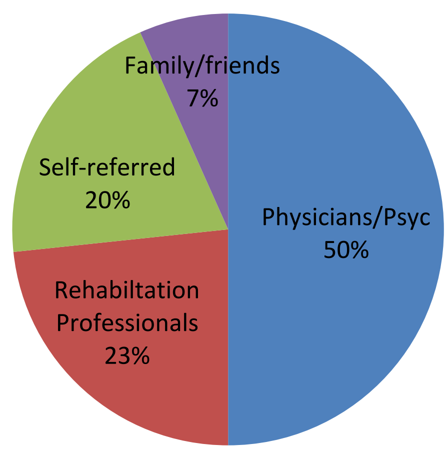

Figure 3: Referral sources of TBI patients

RESULTS

The mean age of the TBI group was 40.4 (age range: 10 to 85) with 57% being female, and the mean age of the normal group was 25.4 (age range: 9 to 64) with 43% being female. Figure 3 showed the referral sources of the TBI patients. The majority of the TBI patients were referred by another medical, psychological, or rehabilitation professional (73%). Of the six self-referred TBI patients (20%), all six had a history of significant trauma. Three reported onset of visual symptoms after falling, one was hit in the head by a falling child in the playground, one had 2 incidences of trauma (car accident and domestic abuse), and the last one had 3 incidences of trauma (fell off ski lift, hit diving board, and bike accident). The two patients (7%) who were referred by family/friends had history of significant car accidents. Analysis of the refractive status of the TBI patients showed that 15 of the subjects (50%) had refractive error of less than +/- 1.00 DS, 1.00 DC, and/or 1.00 DS of anisometropia. Of all 30 subjects, only one (3%) had anisometropia of >1.25 DS and the remaining 29 (97%) of the subjects had anisometropia of <1.00DS. Therefore, the impact of refractive error on VMSS in this study is expected to be minimal.

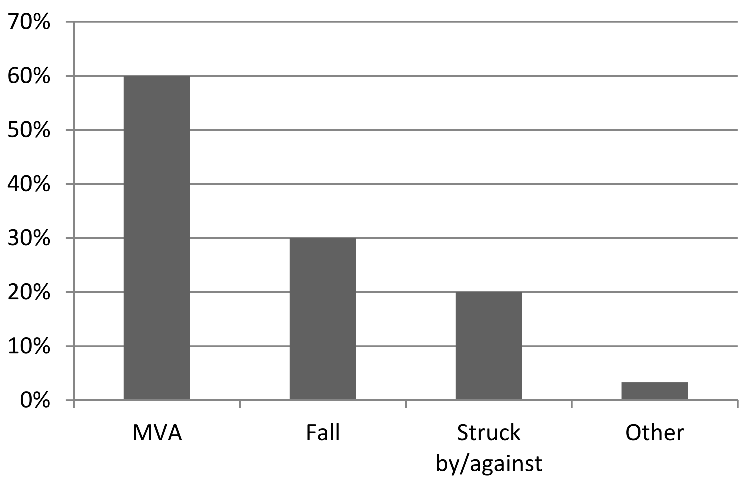

Figure 4: Causes of TBI

Figure 4 showed the causes of the TBI (the percentages in Figure 4 added up to be more than 100% because some patients had suffered TBI from two or more causes). The most prevalent causes of the TBI in our study were motor vehicle accidents (60%), fall (30%), struck by/against (20%), and other (3%). A much higher prevalence of VMSS was found in the TBI group (93%) compared to the non-TBI group (13%) (Figure 5). Chi-Square analysis was performed and the difference was found to be statistically significant (Table 1, p-value

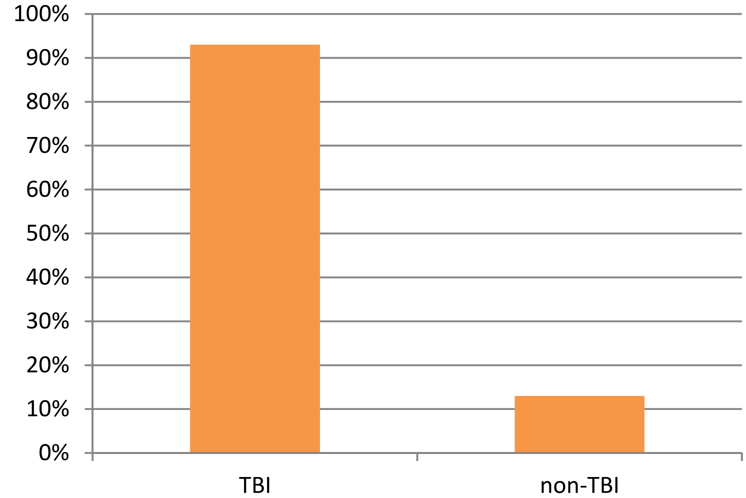

Figure 5: Prevelance of VMSS in TBI vs non-TBI

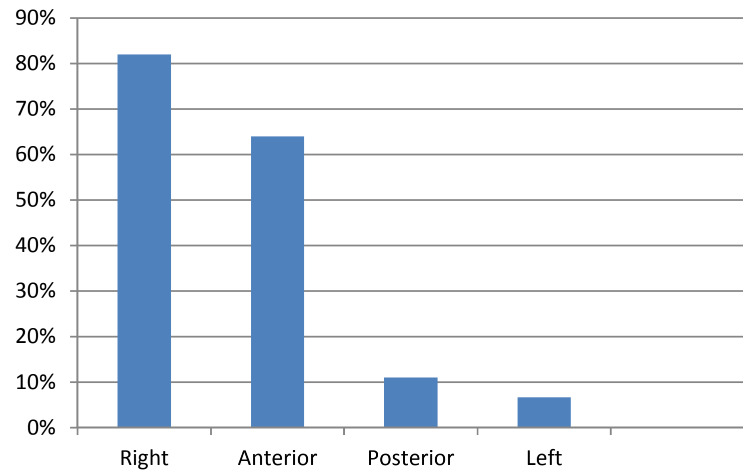

Figure 6: Prevalance of VMSS Direction in TBI group.

Table 1. Chi-Square Analysis (TBI vs. non-TBI)

Chi-Square Test

*p-value of <0.0011

	TBI (N = 30)	Non-TBI (N = 30)
VMSS	28*	4
No VMSS	2	26
Percentage	93%	13%

<0.0011). As shown in Figure 6, the directions of VMSS found in the TBI group in order of prevalence were right (82%), anterior (64%), posterior (11%), and left (7%). It is interesting to

note that right VMSS and anterior VMSS were significantly more prevalent than left VMSS or posterior VMSS in our TBI patients. Further analysis using the Chi-Square Goodness-of-Fit Test showed that the prevalence of Right VMSS is statistically higher than Left VMSS or no Right/Left VMSS. (Table 2, p-value < 0.001) and Anterior VMSS is statistically higher than Posterior VMSS or no Anterior/Posterior VMSS (Table 3, p-value = 0.002)

Table 2. Chi-Square Analysis (Right vs. Left VMSS)

Right vs. Left VMSS

Chi-Square Goodness-of-Fit Test

***p-value of <0.001**

	Right VMSS	Left VMSS	Neither Right/Left
N = 28	23*	2	3
Percentage	82%	7%	11%

Table 3. Chi-Square Analysis (Anterior vs. Posterior VMSS)

Anterior vs. Posterior VMSS

Chi-Square Goodness-of-Fit Test

***p-value of 0.002**

	Anterior VMSS	Posterior VMSS	Neither Anterior/ Posterior
N=28	18*	3	7
Percentage	64%	11%	25%

DISCUSSION

The results of our study showed that VMSS is highly prevalent in patients with TBI compared to patients with no history of TBI. Since VMSS was found to interfere with daily activities that involve balance, posture and/or visual spatial awareness and it is treatable with yoked prisms, the key clinical implications of this study is that VMSS testing should be performed in all TBI patients. The reason that our study found a much higher prevalence of VMSS than the other two studies was most likely because our VMSS testing was performed in three gazes (instead of primary gaze only) and it was repeated in both directions (instead of one direction only). This detailed testing protocol likely allows for the detection of subtle VMSS cases. Further, our study involves TBI patients only whereas the Padula study involved CVA patients only[3] and the Bansal study involved a mix of TBI and other brain injury patients.[2] It is possible that the exact prevalence of VMSS is different in TBI versus CVA and other brain injuries.

The limitation of the current study included being retrospective, unmasked, single center and that the VMSS Test is a subjective test. There is also an age difference between our TBI group (40.4) and the control group (25.4). The control group's average age was lower since this practice sees many young patients for general optometric examinations, whereas many TBI patients seen at this practice are adults. One other potential limitation of this study was that VMSS was measured with the examiner positioned to the right of the patient to maintain a standardized procedure. It was the clinical experience of the first author that there are more Right VMSS than Left VMSS. Therefore, standing to the right side of the patient was chosen since it is typically easier to observe a subtle Right VMSS when standing to the patient's right side. The examiner's position is not expected to have a huge impact on the results since the same method of VMSS testing was also performed on the control group. Future studies, especially using objective measuring devices, could investigate if examiner position may affect the outcome of VMSS testing.

The next research project will attempt to determine if the higher prevalence of Right

VMSS may be correlated to factors such as eye-dominance, hand-dominance, rapid naming ability or the causes of TBI. Future research could also focus on development of an objective test for VMSS utilizing computerized recording to remove any bias. In the long-term, prospective, masked, multi-center study should be considered.

CONCLUSION

The prevalence of VMSS is extremely high in patients with TBI. Our study also found a much higher prevalence of right or anterior VMSS compared to either left or posterior VMSS. Our data supported VMSS testing to be performed on all patients with a history of TBI.

Acknowledgement

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Equipment Source:

[a] Optometric Extension Program Foundation. 2300 York Road, Suite 113, Timonium MD 21093, www.oepf.org, (410) 561-3791

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