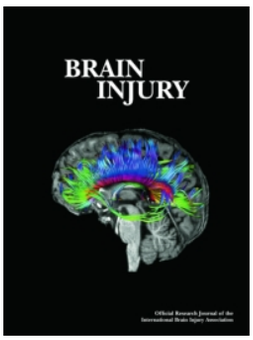

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Treatment of vertical heterophoria ameliorates persistent post-concussive symptoms: A retrospective analysis utilizing a multi-faceted assessment battery

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Abstract

Primary objective: To examine the effectiveness of neutralizing prismatic lenses for reduction of headache, dizziness and anxiety in patients with persistent post-concussive symptoms and vertical heterophoria (VH).

Background: Approximately 5–10% of patients with traumatic brain injury (TBI) develop persistent post-concussive symptoms. Many rehabilitation/treatment modalities are tried, but are largely unsuccessful, indicating a need for more effective treatment.

Design and method: This retrospective study included 38 patients with persistent post-concussive symptoms, who were diagnosed by an optometric binocular vision sub-specialist with VH (a sub-set of binocular vision dysfunction [BVD] that manifests as vertical eye and image misalignment). Data was collected both before and after prism application and included validated survey instruments for headache, dizziness, anxiety and BVD symptom burden; subjective rating (0–10 scale) of headache, dizziness and anxiety severity; and a sub-analysis of the BVD survey instrument questions that pertain specifically to headache, dizziness and anxiety. Upon conclusion of treatment, subjective assessment of overall improvement of heterophoria symptoms was obtained utilizing a 10 cm visual analogue scale.

Outcomes: Results demonstrated marked reduction in all measures of headache, dizziness and anxiety (19.1–60.8%) and an overall subjective improvement of VH symptoms of 80.2%.

Conclusions: Neutralizing prismatic lenses are an effective treatment of headache, dizziness and anxiety in patients with persistent post-concussive symptoms and VH.

Keywords

anxiety, Attention Deficit Disorder/Attention Deficit Hyperactivity Disorder (ADD/ADHD), binocular vision dysfunction, convergence insufficiency, dizziness, headache, post-concussive symptoms, prism lenses, reading or learning disability, TBI, vertical heterophoria

History

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Introduction

Brain injury is a common occurrence, with recent estimates that TBI is responsible for 280 000 hospitalizations and 2.2 million emergency department visits annually in the US alone [1]. While the majority of patients with concussion can expect a full recovery, persistent post-concussive symptoms can occur in ~ 5–10% of patients, despite many different types of therapies, treatments and medications. Identification of an effective treatment modality would be of great benefit to this cohort.

It is well established that vision dysfunction (including binocular vision dysfunction [BVD]) is precipitated by TBI [2–8]. Previous work has identified vertical heterophoria (VH; a sub-set of BVD that manifests as vertical eye and image misalignment) in a group of patients with persistent post-concussive symptoms and that treatment of the misalignment with neutralizing prismatic lenses resulted in marked reduction of the headache, dizziness and anxiety in that cohort [2].

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Estimates of vertical eye misalignment range from 7–52%, with best estimates at ~ 20% of the general population [9–11]. These wide ranges testify to the difficulties involved in the identification, quantification and treatment of vertical misalignment. There appear to be three main factors contributing to this difficulty:

(1) The many associated symptoms of vertical misalignment are diverse. While they are often associated with numerous other medical conditions, they usually are not associated with vision misalignment (Figure 1).
(2) The battery of tests used to identify and quantify vertical misalignment fail to accurately determine the magnitude and orientation of prism needed [10,12–19]. These tests include both dissociated phoria tests (Von Graefe phorias [near and far], vertical vergence testing, red lens test, Bernell light box with Maddox rod, Titmus tester) and associated phoria tests (Mallett unit, Wesson Card, AO Vectographic slide). For example, patients who are eventually determined to have symptomatic VH can have test results that indicate no vertical misalignment or that indicate a hypophoria when a hyperphoria is present [2,13].

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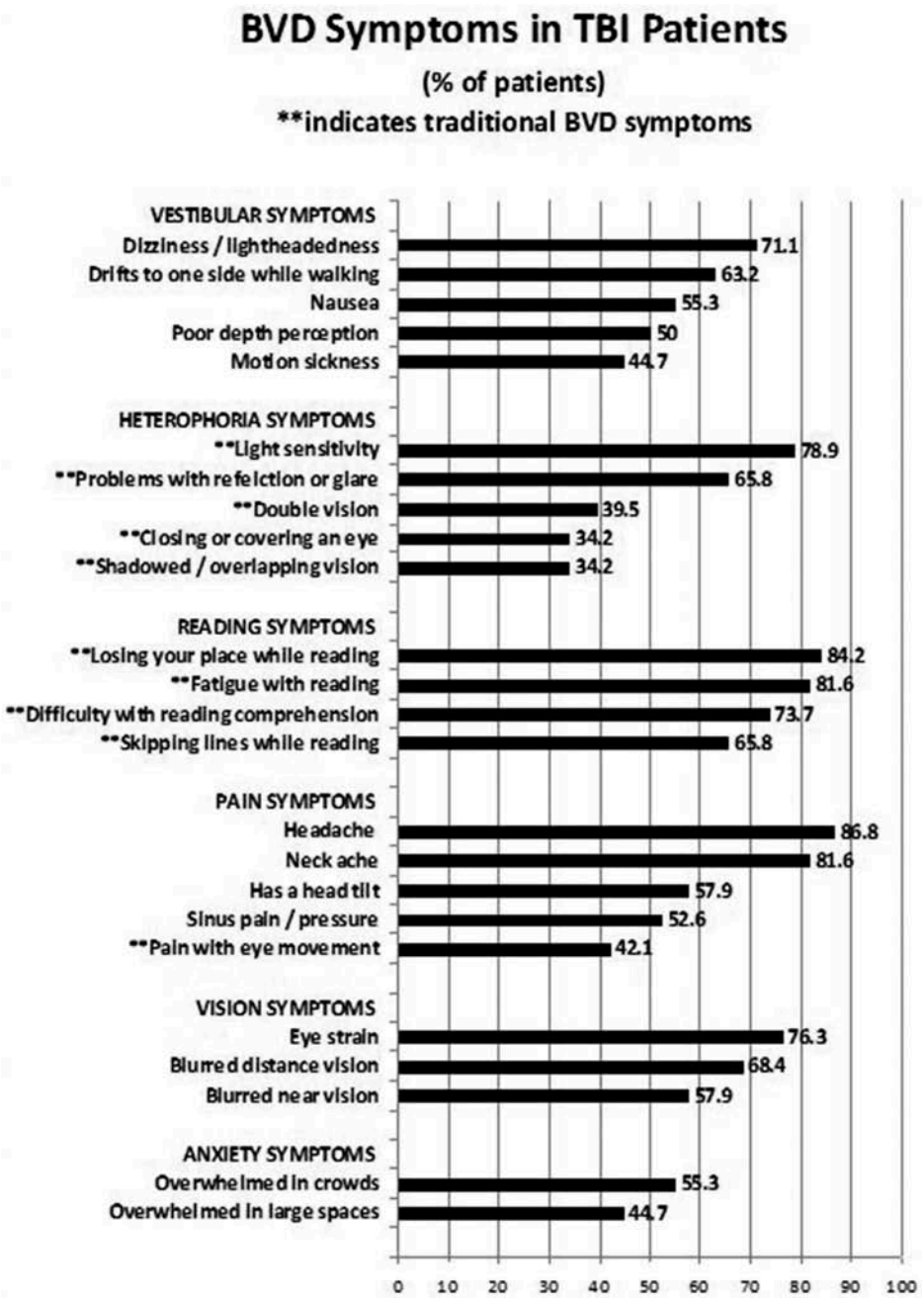

Figure 1. BVD symptoms in TBI patients (% of patients). ** Indicates traditional BVD symptoms.

(3) The amount of neutralizing prism does not appear to correlate with severity of symptoms. Patients can be very symptomatic with only small amounts of misalignment.

With a lack of clear and actionable vertical alignment diagnostic tests and the diverse nature of BVD symptoms and symptom severity, VH is rarely diagnosed by the current vision and general medical communities. Instead these patients are evaluated by many different providers and are subjected to multiple tests and their symptoms are incorrectly ascribed to a variety of medical conditions including atypical migraines, muscle tension headaches, sinusitis, Meniere's disease (typical and atypical), anxiety, panic attack, Attention Deficit Disorder/Attention Deficit Hyperactivity Disorder (ADD/ADHD), convergence insufficiency, reading or learning disability and persistent post-concussive symptoms [2,10].

This necessitated the creation of a new method to diagnose vertical eye misalignment to allow for the identification of patients who are amenable to treatment with neutralizing prismatic lenses [2]. This method, known as the Prism Challenge test, is utilized in this study and is described in the Methods section.

The purpose of this paper is to expand upon the previous report utilizing a much broader array of measurements in order to examine the effectiveness of neutralizing prismatic lenses for reduction of headache, dizziness and anxiety in patients with persistent post-concussive symptoms and VH.

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Methods

This retrospective study was approved by Western IRB. Thirty-eight patients with a history of persistent post-concussive symptoms, who presented to an optometric binocular vision sub-specialist and were simultaneously diagnosed with VH, who completed both phases of treatment and who had complete data sets were included in this retrospective analysis.

The examination phase consisted of a complete ocular and refractive exam coupled with a detailed binocular vision examination, which included vertical vergence testing, Von Graefe phoria testing near and far, Titmus tester and utilization of the Bernell light box (all are dissociated phoria tests). Also, the presence and direction of a head tilt was noted.

For the purposes of this study, VH diagnosis was established by the optometrist with the Prism Challenge test. This test consists of the incremental addition of small units of neutralizing vertical prism (usually 0.25D) to a trial frame containing the patient''s refractive prescription. The test is considered positive, the patient is diagnosed with VH and the vertical prism prescription is established when the accumulated vertical prism prescription results in a marked reduction or elimination of BVD symptoms.

The treatment phase entails the patient wearing the initial refractive and prism prescription (as determined by the Prism Challenge) for 2–4 weeks, allowing their visual system to progressively relax. As this occurs, patients most often require one or two adjustments (usually minor) to their prescription.

Data collected prior to prism intervention included baseline demographics and a detailed review of systems (ROS). Data collected prior to and at the conclusion of prism intervention included results from:

(1) validated survey instruments including the Headache Disability Index (HDI), Dizziness Handicap Inventory (DHI), Zung Self-Rating Anxiety Scale (SAS) and from the Binocular Vision Dysfunction Questionnaire (BVDQ) (a validated, self-administered BVD symptom assessment instrument developed by the authors to determine BVD symptom frequency);
(2) a subjective rating (0–10 scale) of headache, dizziness and anxiety severity; and
(3) a sub-analysis of the BVDQ survey instrument questions that pertain specifically to headache, dizziness and anxiety.

Upon conclusion of treatment, subjective assessment of overall improvement of BVD symptom burden was obtained utilizing a 10 cm visual analogue scale (VAS) and the effect of treatment was analysed using paired *t*-test. The final cumulative prism prescription was recorded.

Results

In this study, 13 participants (34.2%) were male and 25 (65.8%) were female. The average age was 38.2 years old, with a range of 12–67 years old. Average duration of symptoms was 9.9 years (range = 3 months to 30 years). Prior to intervention, glasses were worn by 28 (73.7%) and contact lenses by five (13.2%). Eye surgeries were reported by three patients (7.9%). Brain CT scans were performed for 26 (68.4%), brain MRI was performed for 23 (60.5%) and both tests were performed for 19 (50%). Presenting complaint, frequency of consultations with specific types of providers prior to binocular vision assessment and prevalence of confounding diagnoses are listed in Figures 2–4.

Symptom prevalence

A detailed ROS was performed and included questions concerning heterophoria symptoms, reading symptoms, pain symptoms, standard vision symptoms, vestibular symptoms and anxiety symptoms (Figure 1).

Except for light sensitivity (78.9%) and problems with reflection and glare (65.8%), none of the other heterophoria symptoms (34.2–39.5%) were reported as frequently as any of the other symptoms reported, including headache (86.8%), neck ache (81.6%), dizziness (71.1%), nausea (55.3%), all

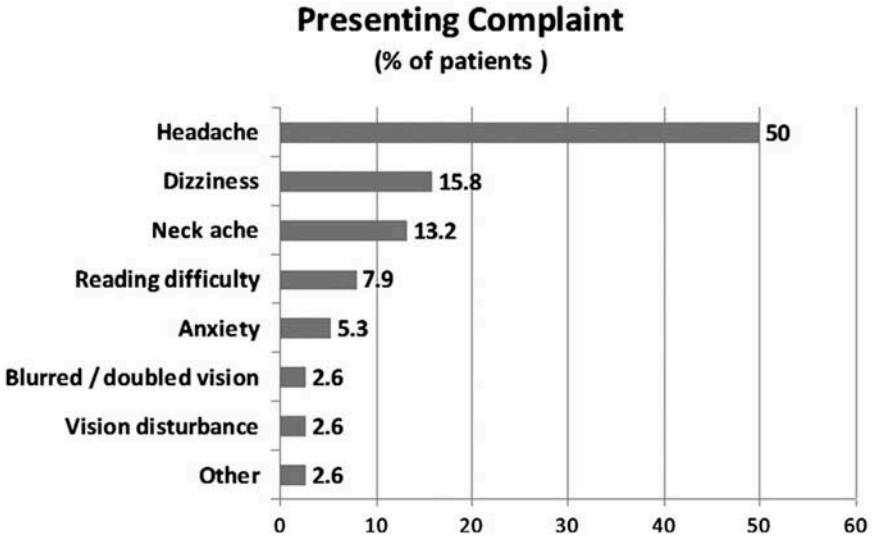

Figure 2. Presenting complaint (% of patients).

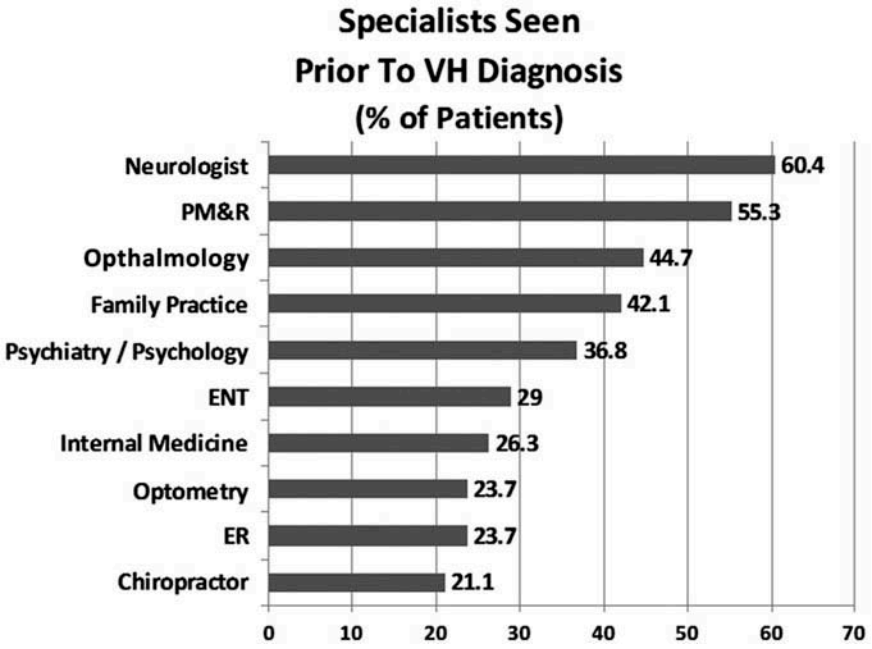

Figure 3. Specialists seen prior to VH diagnosis (% of patients).

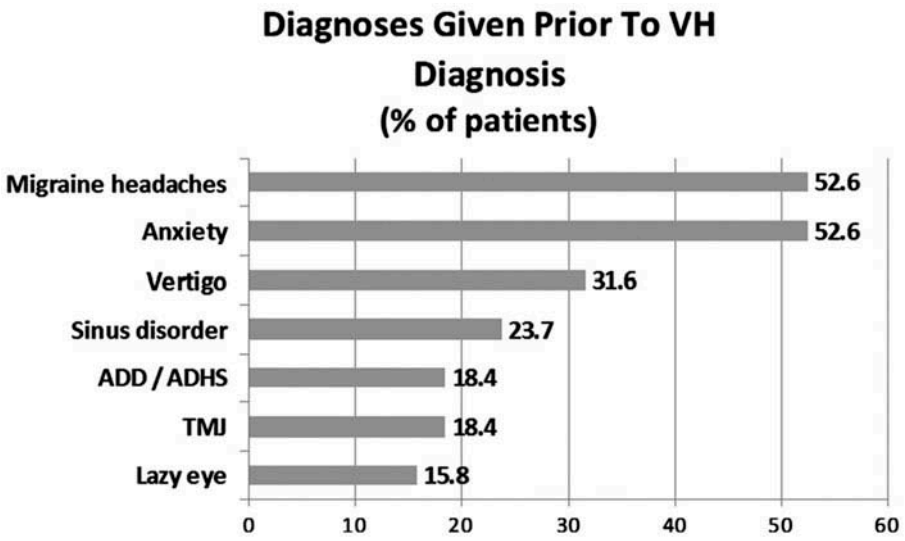

Figure 4. Diagnoses given prior to VH diagnosis (% of patients).

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reading symptoms (65.8–84.2%), eye strain (76.3%) and feeling anxious/overwhelmed in crowds (55.3%).

Pre-treatment metrics

Vertical alignment tests performed poorly in predicting the direction of the misalignment (16.2–64.7%). Only the observed direction of the head tilt had some predictive value (83.3%) (Figure 5).

Pre- and post-treatment metrics

When compared with the pre-intervention baseline, there was an 80.2% decrease in subjective overall BVD symptom burden as measured by the VAS ($p = 0.0001$). There was a relative reduction (i.e. percentage change) in the BVDQ (50.5%; $p = 0.0001$). The validated survey instruments for headache, dizziness and anxiety burden experienced a relative reduction between 19.1–40.7%. The subjective rating (0–10 scale) for headache, dizziness and anxiety burden experienced a relative reduction between 33.9–60.8%. The sub-analysis of the BVD survey instrument questions that pertain specifically to headache, dizziness and anxiety experienced a relative reduction between 42.1–51.2% (Figure 6).

Post-treatment metrics

Vertical prism prescription between 0.5–2.00 dioptres was noted for 68% of the patients, between 2.50–4.00 dioptres for 29% and greater than 4.00 dioptres for 3% (one patient). The average duration of treatment was 10.5 weeks (range = 3–28 weeks).

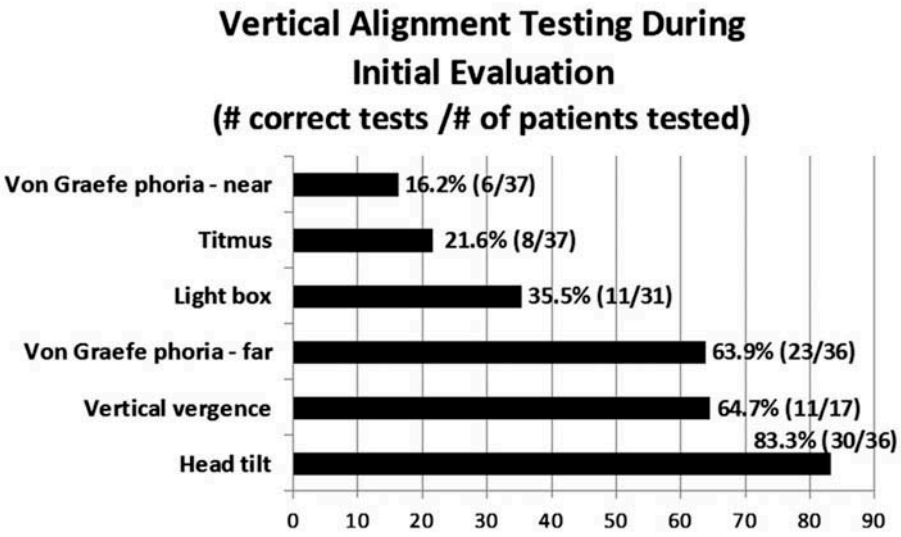

Figure 5. Vertical alignment testing during initial evaluation (# correct tests/# patients tested). A test was considered 'correct' if it identified that a vertical misalignment was present and if it correctly identified the direction of the misalignment. Not every test was performed on every patient.

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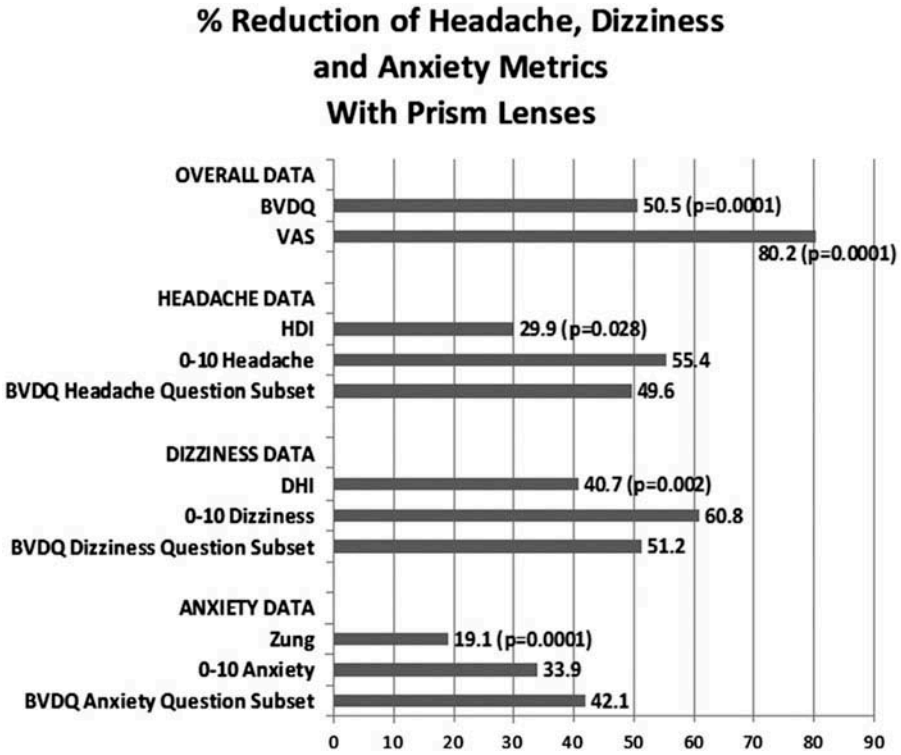

Figure 6. Percentage reduction of headache, dizziness and anxiety metrics with prism lenses.

Discussion

Identification of VH (a form of BVD) in this TBI patient cohort and treatment of the misalignment with neutralizing prismatic lenses led to a marked reduction in all metrics for symptoms of headache, dizziness and anxiety, as well as for subjective metrics on overall symptom reduction (Figure 6). Approximately 30–50% reduction of symptoms occurred within 30 minutes of the application of neutralizing prism.

This is consistent with the theory that the symptoms of BVD are occurring due to competition between a faulty vertically misaligning vestibular reflex and a corrective fusional reflex. This appears to cause the opposing elevators and depressor EOMs to struggle against each other, resulting in EOM over-use and rapid but minute back and forth vertical eye movements (which are frequently perceived as visual hallucinations of movement such as shimmering or vibrating of letters on the page). The EOM over-use results in headache and face pain, while the eye movements result in dizziness, nausea, motion sickness and other 'vestibular' type symptoms. The prism lenses appear to be supplanting the corrective fusional response, thereby breaking up the 'tug-o-war' cycle, relieving EOM over-use, diminishing/eliminating back

and forth vertical eye movements and allowing for a significant reduction of symptoms almost immediately.

The 10.5 week duration of treatment is consistent with the overall clinical experience of 8–12 weeks and it is during this time that the 1–3 changes in the lens prescription are required to address the progressive relaxation of the EOMs and what appears to be the re-equilibration of the binocular visual system.

This study demonstrates the ability of the Prism Challenge test and the BVDQ to function together to diagnose BVD in patients with TBI and initiate treatment, assess effectiveness of treatment and make changes to the treatment to improve outcome. Utilizing this approach over the last 20 years, 3000 patients with BVD and TBI have been identified, treated and observed. This has allowed for clarification of the set of BVD symptoms in patients with TBI, many of which are not usually associated with BVD (Figure 1). This approach holds great promise for further studying of BVD in patients with TBI and it's associated symptoms.

In this study multiple dissociated phoria tests were found to lack adequate sensitivity in identifying the existence and/or the direction of vertical misalignment in this cohort of patients with minute but symptomatic vertical misalignment. This is consistent with previous reports [10,12–19]. It is for this reason that this diagnostic and treatment approach does not rely upon these 'objective' measurements, but uses instead the patient's subjective reduction of symptoms in response to incremental changes in prism (i.e. Prism Challenge), which in this study has been a much more reliable method of identifying the prism needed to neutralize the vertical heterophoria and reduce the associated symptoms. It is of interest to note that the presence of and direction of a head tilt as observed during physical examination was the most accurate assessment of the presence of and direction of the vertical misalignment (Figure 5).

In this study males were a minority at 34.2%. This is unusual for a TBI cohort, but might be explained by the fact that the most prevalent presenting complaint by far in this group was headache (50%; Figure 2), which is much more common in females than males.

Almost every patient in this study had either a very small amount or small amount of vertical misalignment (68% had accumulative vertical prism prescription between 0.5–2.00 dioptres and 29% were between 2.50–4.00 dioptres) and yet were quite symptomatic (average HDI = 46.5; DHI = 39.7; Zung = 42.8) and improved significantly with neutralizing prismatic lenses. This emphasizes the need to be able to identify and treat heterophorias requiring very small amounts of neutralizing prism, as they can precipitate significant morbidity [13].

Study limitations

This is a retrospective study and, as such, has the potential to introduce certain biases into the data and into the interpretation of that data. Furthermore, given that this line of inquiry is new, this is currently the only centre reporting data on this at this time. However, the authors have begun the process of training other vision care providers in these techniques and it is anticipated that multi-centre trials will be performed in the future.

Patients were not diagnosed with VH utilizing a vertical misalignment measurement, but rather with a combination of history, physical findings and a positive response to prism lenses (i.e. symptom reduction with Prism Challenge). To the authors knowledge there isn't a single device or test which can accurately measure the small amounts of vertical misalignment found in this population. Discovering such a device or test would greatly simplify the process of identifying and treating this patient cohort and is currently one of the research priorities.

The percentage of patients with persistent post-concussive symptoms who also have BVD could not be determined from this retrospective study. Additional studies will be required to obtain this important datum.

Conclusions

In patients with persistent post-concussive symptoms and VH, identifying and correcting the visual misalignment with neutralizing prismatic lenses markedly reduces the persistent post-concussive symptoms of anxiety, dizziness and headache utilizing multiple metrics. These findings support previous studies describing an association between TBI and visual system injury, particularly parts of the vision system controlling image alignment. While further study (including prospective studies and multi-centre studies) is indicated, the positive attributes, minimal risks and cost effectiveness of this therapeutic approach make screening for and treating BVD in this patient population a consideration, particularly in the face of less than desirable outcomes of the standard treatment modalities.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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