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The Use of Therapeutic Microprism for Patients with Post-concussion Syndrome

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Keywords

• Microprism • Base in prism • Concussion • Neuro optometry
• Neuro rehabilitation • Post-concussion syndrome • Vision rehabilitation

Key points

- Concussion, brain injuries, and other neurologic conditions carry a high incidence of visual symptoms and findings.
- The common visual sequalae of post-concussion syndrome (PCS) often includes convergence insufficiency, deficiencies of oculomotor function, accommodative deficits, as well as visual perceptual and visual vestibular and visual motor deficits.
- Small amounts of prism (microprism), along with other treatments, can be used to reduce symptoms in the patient with PCS
- Neuro Optometric Rehabilitation and microprism should be considered for all patients with all patients that have suffered concussion.

INTRODUCTION

A concussion is a mild subtype of Traumatic Brain Injury (mTBI) that affects brain function [1,2]. However, the term "mild" should not be equated with insignificant. Symptoms following mTBI vary greatly from patient to patient and the length of time an individual experiences these effects also varies greatly. Post Trauma Vision Syndrome (PTVS) presents as the most common visual sequelae of mTBI, encompassing a variety of signs and symptoms that

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may include convergence insufficiency (CI), accommodative dysfunction, minimum blink rate, reduced concentration or attention, oculomotor deficits, and visual-spatial distortion often associated with an abnormal egocentric localization [3].

Because symptoms of PTVS occurring in patients with mTBI and symptoms of Post-Concussion Syndrome (PCS) are so similar, in this article we will use the terms mTBI and PCS interchangeably. Most patients also experience significant non-visual symptoms that linger in PCS, ranging from sleep disturbances and cervical strain to increased levels of anxiety and depression [4]. Co-management with physical and occupational therapists, chiropractors, speech/language therapists, neurologists, and physiatrists, therefore, is indicated for many patients diagnosed with mTBI.

The prognosis for full visual recovery following a concussion is generally positive. Many treatment options exist, depending on the severity of symptoms, including lenses, prisms, and optometric vision therapy [5–7]. As reviewed by Press [8], the term microprism was originally introduced by Bowan to denote low amounts of therapeutic base-in prism typically in the range of 1 prism diopter but also can apply to other base orientations of the prism. Microprism has gained traction as a successful tool in optometric visual rehabilitation.

The approach detailed by Press makes use of conventional tools to probe indications for microprism, as one would do for convergence insufficiency and other forms of binocular dysfunction. These include associated phoria, fixation disparity, free space fusion, jump vergence, and stereopsis. While we make use of these tools for the binocular evaluation of patients with mTBI, we have found other means of clinical assessment valuable as well. These probes are addressed in the section that follows and are illustrated through a case series of 5 patients.

CLINICAL ASSESSMENT

Our approach to therapeutic interventions for PCS begins with identifying symptomatic problems through the Brain Injury Vision Symptom Survey (BIVSS). The BIVSS is a 28-item symptom checklist that has shown 82.2% sensitivity in predicting TBI [9]. The BIVSS, reproduced in Appendix 1, shows very good test-retest reliability, enabling it to serve as a valuable tool for assessing and quantifying visual symptoms associated with mild to moderate TBI [10]. The BIVSS lets patients share their symptoms based on frequency of occurrence rather than severity or intensity of symptoms. This allows much more accurate tracking of symptoms over time, as patients may adjust their perceived pain levels as healing begins to occur. The BIVSS has become an essential component in documenting the patient's case history, adding confirmation to the visual elements of PCS.

In addition to static tests behind the phoropter, the clinical tests that we commonly employ for this population are dynamic and tap heavily into the vestibular and ocular motor systems [11,12]. In particular, we use a modified version of the Visual/Ocular Motor Screening (VOMS). VOMS testing, detailed in Appendix 2, includes smooth pursuits, saccades, near point of

convergence (NPC), vestibulo-ocular reflex (VOR) testing, and visual motion sensitivity testing (Figures not included). Our symptomatic PCS patients typically report subjective discomfort that is exacerbated during VOMS testing. Objectively, when measuring patients with PCS, one often notes a receded endpoint for the NPC, increased "jerky" appearance or head movement in their pursuits and saccades, and visible discomfort while performing the VOR testing. In addition, we conduct a standard optometric binocular vision evaluation including tests of ocular health, visual field, egocentric localization, sensory and motor fusion, accommodation, and vergence ranges.

Headaches are a common complaint in mTBI, but can potentially be a sign of neurologic insult within the visual pathways. We therefore routinely conduct automated perimetry with the Octopus 30-2 visual field test. Visual field abnormalities are common following mTBI and can vary from small scotomas, generalized constriction, homonymous hemifield loss, or in extreme cases total visual field loss [13]. (Fig. 1) Abnormalities that are due to visual hypersensitivity following a concussion will be transient and often resolve if the test is repeated; those that are due to structural damage will not.

The visual evoked potential (VEP) test is not routinely used in clinical practice but can be utilized to assess the patient with PCS. That is because it is a measure of the amount of information (amplitude) and transmission time (latency) from the eyes through the optic nerves to the occipital lobe. No other objective test exists that provides this information. Pattern visually evoked potentials (VEPs) were run as a baseline and again to determine response to treatment lenses. Patients with PTVS show decreased VEP amplitude and latency, often normalizing with the application of binasal occlusion and low amounts of base in prism [14,15].

Once the clinical profile of a patient with PTVS is established utilizing a neuro-optometric rehabilitation assessment that includes the BIVSS, VOMS, binocular assessment, and the VEP, the data are factored together with the refraction to formulate a tentative spectacle lens Rx. As noted by Press, the binocular profile often points to improved convergence, improved stereopsis, more balanced ranges, more stable associated phoria or fixation disparity, improved stereopsis, and a greater sense of comfort or clarity when conventional binocular probes are repeated through microprism in the horizontal

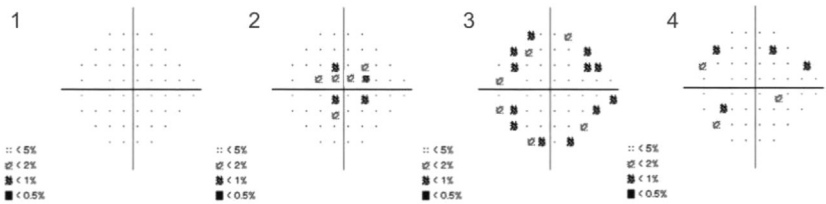

Fig. 1. Examples of typical outcomes of visual field testing in patients following a concussion/mTBI. (1) normal field with no defects, (2) central depression, (3) generalized constriction 360, (4) scattered depression with no neurologic pattern.

and/or vertical direction [8]. We have found analogous changes when our probes utilizing the BIVSS, VOMS, and VEP are repeated through the tentative microprism derived through the binocular assessment, typically 0.5^ or 1.0^ micro prism base-in or base-down.

Based on improvement in scores on the BIVSS and VOMS, and improvement in VEP latency or amplitude, microprism is incorporated into the Rx. Although many patients accept the same microprism at distance and near, if trial framing indicates different values at distance and near, we dispense 2 separate Rxs as appropriate. When the patient's BIVSS indicates photophobia or light sensitivity as a significant symptom, we present the option of adding tinting to the prescription as well. This includes FL41, Blutech, Avulux, 10% blue, or polarized sunglass tints to complement a rehabilitation program. Although vision therapy remains an important approach for patients with mTBI, we found that lenses and prisms in some cases can result in instantaneous symptom reduction, are cost-effective, and require minimal time or patient effort.

CASE SERIES RESULTS

The 5 representative patients assessed ranged from 17 to 60 year old. One patient suffered from a fall resulting in a head injury, 1 patient had a sports-related head injury, and 3 patients were injured in motor vehicle accidents.

Table 1 shows the initial BIVSS scores. As noted previously, the BIVSS is a 28-item questionnaire. It has a Likert scale of 0 to 4, and, if the maximum score of 4 is recorded for each question, the total is 112. The scoring is based on how frequently a patient will experience symptoms, with a 0 correlating to "never" and a 4 correlating to "always." Patients diagnosed with brain injury typically have a score greater than 32; the BIVSS scores for our patients ranged from 39 to 60. The middle column of Table 1 indicates the primary symptoms that patients were hoping to address through treatment.

Patients were asked to rate the increase in symptoms during VOMS testing on a scale of 0 to 10, with 0 being no increase, and 10 being an intolerable increase in symptoms. Those scores are contained in the last column, with H and

Table 1
Patient information for the 5 patients included in the case series

Patient	Age	BIVSS	Main symptoms	VOR/Visual motion rating
AG	60	44/112	Reading issues, HA, motion sickness	H 4/10, V 4/10, C 4/10
LC	53	60/112	Dizziness, HA, reading issues	H 5/10, V 5/10, C 6/10
LB	17	54/112	HA, reading issues	H 0/10, V 0/10, C 5/10
BA	27	44/112	Light sensitivity, HA	H 6/10, V 6/10, C 7/10
AG	29	39/112	Light sensitivity, HA, dizziness	H 0/10, V 4/10, C 5/10

BIVSS scores were taken during their first assessment, at this time patients were asked the main symptoms they felt impacted activities of daily living. The VOR rating was the patient's subjective assessment during the VOR testing.

V indicating the horizontal and vertical components of the VOR respectively, and C indicating the motion sensitivity score.

The VEP was used to objectively determine patients who had a binocular dysfunction present and those who had ambient dysfunction. For our testing, binocular dysfunction is defined as present when the binocular summation of visual information is not greater than the visual information obtained by each eye separately. Ambient dysfunction is more complex, as it involves the magnocellular pathway and will often present more as symptomology rather than clinical measurements. Patients with ambient dysfunction often describe their symptoms as worsening while driving, in visually busy environments like big box stores, and with fluorescent lighting. The magnocellular pathway is responsible for visual sensitivity and visual motion processing [16], and with the motion in the pattern VEP, we can monitor how patients respond with and without lens treatments in place to determine if they have an ambient dysfunction present. Patients who have higher amplitudes or quicker latencies in the VEP data with the treatments in place show a positive response, meaning that they have a dysfunction present.

Table 2 shows the VEP data indicating that binocular dysfunction was present with ambient dysfunction in each patient, and that each patient experienced improved function with the prism in place. Baseline testing was done with the best-corrected refraction in place. Then the test was re-administered with 2.0 prism base in (BI) oculus uterque (OU) added to the Rx, followed by binasal occlusion. A higher prism was intentionally used for testing compared to prism that was trialed and prescribed based on published protocols [14]. Assessment of binocular vision dysfunction through the VEP data was done by comparing oculus dexter (OD), oculus sinister (OS), and OU amplitudes and p100 latency. Patients who were identified as having a binocular dysfunction through the VEP showed either a reduction in amplitudes or increased latency with OU testing as compared to monocular testing. While amplitude reflects focal vision indicative of visual acuity, latency is indicative

Table 2
The following table illustrates the VEP results from each patient

	VEP results			
Patient	Binocular dysfunction	Ambient dysfunction	2 BI improved function	30–2 visual field
AG	Yes	Yes	Yes	Generalize constriction OU
LC	Yes	Yes	Yes	Scattered central depression OU
LB	Yes	Yes	Yes	Scattered central depression OD, full field OS
BA	Yes	Yes	Yes	Full field OU
AG	Yes	Yes	Yes	Full field OU

The baseline results were analyzed to determine which patients suffered from a Binocular Dysfunction and which from an Ambient Dysfunction. The VEP was repeated with a total of 2 prism base-in, consistent with previously published guidelines (14) to assess which patients showed improved function. The results of the 30-2 visual field to rule out neurologic damage are included.

of ambient dysfunction, defined as difficulty with visual processing involved in balance, movement, coordination, and posture [14]. A deficit in binocular summation of the amplitude, or a decrease in latency that improved when repeated through 2° BI, typically indicates that the patient would benefit from our treatment protocol.

An Octopus 30-2 visual field test was administered to all patients due to the frequency and severity of reported headaches. The visual field results were used to rule out pathology or other insidious causes of new-onset headaches. It also was used to assess peripheral vision as might be related to driving ability in all patients. The baseline results are listed showing the variety in field changes following a traumatic brain injury (TBI): 2 patients presented with normal fields, 2 with scattered areas of depression showing no neurologic patterns, and 1 with generalized constriction 360° (see Fig. 1 and Table 2). A scattered pattern or generalized constriction of the field of vision is common in patients with concussion, often they will describe their visual experience as "tunneling" with poor peripheral awareness. Clinically, patients share their struggles and show challenges balancing both central and peripheral visual input, which is likely why visual field testing is so challenging in this population. Further studies are needed to evaluate the fields of post-concussion patients and any cases of long-term "tunneling" following treatment completion. The field results of post-concussion patients show great variability and baseline testing allows practitioners to assess responses to treatment for those patients who present with generalized constriction. Patients without a full field were retested at the 1-month follow up and all showed improvement after full-time use of their prescribed microprism.

In-office testing of balance was performed by observing the patients' typical gait and then using a tandem gait test. A tandem gait test is a simple assessment for imbalance and gait impairment that involves heel-to-toe walking. Its clinical utility in concussion evaluation has been demonstrated in adult, as well as pediatric patients [17]. Depending on the level of gait impairment patients may need a walker, may reach out to touch the walls, or may appear guarded and walk with extreme caution. Observations were made regarding posture, comfort, and fluidity of movement while patients walked heel to toe, in an open area or hallway. All patients showed an improvement in their tandem walk when microprism lenses were in place.

The next area assessed was overhead and fluorescent lighting. Most patients with PCS had elevated scores in the BIVSS section dedicated to "light sensitivity". These symptoms result in complaints that can vary from generalized increased light sensitivity, and headaches triggered by overhead lighting, to the inability to focus during the day at work due to the office lighting. Overhead lighting was observed by the patients with and without the microprism in place. All patients showed immediate subjective improvement, and often reported that the lighting appeared "softer" or "dimmer."

The final subjective assessment of the microprism was completed with an assessment of the computer screen as a visual target. Patients suffering from PCS often report having to limit screen time and reduce work hours or

workload due to the inability to focus on a computer screen. To simulate this trigger, a visually "busy" website was placed in front of the patient and then scrolling movements were added. The patient subjectively assessed visual comfort in their near prescription with and without the microprism in place. Patients reported that computer scrolling became less visually disturbing and the near strain was reduced with the prism in place.

As most PCS patients have heightened peripheral sensitivity, all patients, no matter their age, were trialed in single vision distance lenses, and an appropriate add power was given for a single vision near pair of lenses when warranted. Near plus add powers were determined at the patient's habitual near working distance and due to comfort improvements, often two pairs of lenses were recommended even for pre-presbyopic patients versus progressive or bifocal lenses.

Progressive addition lenses offer advantages, but also strong disadvantages for this population such as peripheral distortion, reduced viewing area, additional head movement to avoid distorted lens area, and an extension head posture when reading. Often removing progressive addition lenses will immediately improve comfort, vergence ranges, headache, and dizziness for patients with PCS.

If patients were not immediately responsive to 0.5ΔBI, the 1.0ΔBI was trialed. In the cases where similar responses were made, the lower 0.5ΔBI was selected. Patients may prefer the 1.0ΔBI at near while they prefer 0.5ΔBI at distance, this is another beneficial reason to prescribe separate distance and near glasses for PCS treatment. All patients included in this report had a beneficial response to 0.5ΔBI, and that was the amount selected for treatment. Lenses were prescribed with no polycarbonate lenses (CR-39 or Trivex) and a tint for comfort. Tinted lenses (typically FL-41 or Blutech®) were trialed and dispensed if the patient noted subjective improvement.

Prisms were worn full-time for 4 weeks to assess subjective improvements. Objective and subjective changes were assessed at a 1-month follow-up appointment. Changes were first assessed with a modified symptom checklist, which emphasized the main areas of the BIVSS, allowing less paperwork for our patients. Questionnaire included patients' assessment of blurry vision (distance and near), double vision (distance and near), light sensitivity, intensity and frequency of headaches, dizziness, and dry eye symptoms as noted in Table 1. All patients experienced improved quality of life after wearing the microprism full-time for the 4 weeks between assessment and follow-up. Many patients felt they could return to driving and handling visually busy environments without the same level of symptoms as before. Two patients also reported an increased ability to work at a computer without a headache. For objective responses, near vergence ranges, smooth pursuits, and near point of convergence were all re-tested at the follow-up. The objective measurements showed a slight improvement in all patients at the 1-month follow-up. The main measure for this treatment outcome was quality of life and subjective symptom reduction; all patients felt it was successful. If patients were advised to begin a program of vision therapy for additional treatment of their symptoms, the full BIVSS would be completed again to have a new baseline with the microprism glasses treatment in place.

DISCUSSION

The recommendation of using passive therapy through microprism was well received by all patients. At the beginning of their recovery, many patients with mTBI are in occupational therapy, physical therapy, or both. Using prism alone is a cost-effective way to reduce symptoms without the added time and financial commitment of additional weekly vision therapy sessions. The prism also allows for improved function during therapy sessions, so patients continue to work at returning to their baseline.

In their article in the inaugural issue of Advances in Ophthalmology [4], Ciuffreda and colleagues emphasized that a small hyperphoria in the range of 0.5 to 1.0 prism diopters found in the asymptomatic non-mTBI population may be problematic in those with mTBI. They noted that vertical vergence compensatory ability appears to be compromised, as is true of their overall vergence function. This mirrors our experience, as illustrated through our case series, that microprism prescribed in the range of 0.5Δ to 1.0Δ has a salient effect on visual symptomology and function. Although the initial probe microprism in our illustrative cases was usually 0.5Δ to 1.0Δ BI, the VEP probe was 2.0Δ BI in line with previously published protocols [14].

The mechanism through which microprism aids this population has not been definitively determined. One explanation is that a neuro-ocular disruption or hypersensitivity in the binocular visual system occurs, such as trigeminal nerve dysphoria. As elaborated by Karpecki, proprioceptive fibers innervating the extraocular muscles provide afferent feedback to avoid binocular misalignments [18]. These signals are transmitted through the ophthalmic branch of the trigeminal nerve and are believed to play a significant role in symptoms such as headache, neck and shoulder pain, light sensitivity, eyestrain, and dry eye. The signs and symptoms of trigeminal nerve dysphoria significantly overlap the symptoms of BIVSS, as well as the signs of PTVS. This is pertinent because the proposed treatment for trigeminal nerve dysphoria is a lens providing a contoured BI microprismatic effect [19]. Another theory is that microprism impacts the VOR and VOR gain, which reduces symptoms of visual motion sensitivity similar to low plus lenses.

An additional theory proposes that the neurologic processing of visual information following a brain injury is much less efficient. Microprism aids in increasing the efficiency and prevents "neural-overflow" to additional areas of the brain. A study that was published in 2012 used visual event-related potentials (VERPs) and MRI to track the neurons that fired in an adult brain when exposed to a visual stimulus, with and without microprism in place [20]. Less number of neurons were fired in the brains with the prism in place. This results in increased processing speeds and reduced symptoms that patients may describe as "brain fog".

While microprism can be successful in reducing symptoms and improving performance in many cases, it is not a panacea when used in isolation. When the outcomes are not satisfactory, we typically probe the addition of binasal occlusion (BNO) to prism glasses. Binasal occlusion has been researched similarly to microprism and showed objective improvements in visual processing VEP data [21]. We probe the effects of BNO when patients have lingering

symptoms of light sensitivity, dizziness, or symptom increase while driving despite lens tinting as noted earlier. More clinical research is needed, but current data show that the combination of microprisms and lens tinting can alleviate ambient vision dysfunction in patients with PCS. When these options are inadequate, we prescribe an individualized optometric vision therapy program for remaining visual deficits.

Over the last few years there has been a rise not only in awareness of the benefits of microprism for PCS, but the benefit of microprism on visual discomfort and symptoms from extensive near work in the general population as well. More patients are aware that visual strain, even without a concussion, is abnormal and it can be reduced with optical strategies. With this becoming more commonplace, more patients are seeking optometrists to help with the reduction in computer or work-related eye strain. Proprietary microprismatic lenses such as the Neurolens [7,19], with a small amount of base-in prism at near added to the distance Rx, are being actively marketed toward primary eye care providers to relieve some of these symptoms.

SUMMARY

The application of microprism shows a therapeutic benefit for many patients with PTVS resulting from concussion/mTBI. Both objective and subjective measures show that it improves visual motion processing and quality of life for symptomatic patients. Given the simplicity of probing microprism in the office, it also should be considered for patients who present with symptoms suggestive of mTBI in the absence of a diagnosed concussion. Symptoms amendable to microprism, present in our illustrative case series, include headaches, balance issues, light sensitivity, and being overwhelmed by visually busy environments. Given the common symptomology profile, patients who have suffered from stroke, chronic migraines, underlying autoimmune diseases, or motion sickness also may benefit from microprism, but that awaits further study.

CLINICS CARE POINTS

- Perform history probing history of acquired brain injury and symptoms.
- Use tools like symptom questionnaires or the BIVSS to efficiently assess common symptoms of acquired brain injury.
- Consider microprism for patients with symptoms of concussion.

Disclosure

The authors have nothing to disclose.

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APPENDIX 1

THE BRAIN INJURY VISION SYMPTOM SURVEY (BIVSS)

BIVSS CHECKLIST (Brain Injury Vision Symptom Survey)

Patient Name: _____ Today's date: _____

My brain injury was: ____ years ago My age is: ____ years today's date: _____

☐ I have had a medical diagnosis of brain injury (check box if true) Cause of injury: _____

☐ I sustained a brain injury without medical diagnosis (check box if true) _____

☐ I have NOT ever sustained a brain injury (check box if true)

Please check the most appropriate box, or circle the item number that best matches your observations. All information will be held in confidence. Thank you for your help!

SYMPTOM CHECKLIST *Circle a number below:*

Please rate each behavior. **How often does each behavior occur?** (circle a number)	Never	Seldom	Occasionally	Frequently	Always
EYESIGHT CLARITY					
Distance vision blurred and not clear -- even with lenses	0	1	2	3	4
Near vision blurred and not clear -- even with lenses	0	1	2	3	4
Clarity of vision changes or fluctuates during the day	0	1	2	3	4
Poor night vision / can't see well to drive at night	0	1	2	3	4
VISUAL COMFORT					
Eye discomfort / sore eyes / eyestrain	0	1	2	3	4
Headaches or dizziness after using eyes	0	1	2	3	4
Eye fatigue / very tired after using eyes all day	0	1	2	3	4
Feel "pulling" around the eyes	0	1	2	3	4
DOUBLING					
Double vision -- especially when tired	0	1	2	3	4
Have to close or cover one eye to see clearly	0	1	2	3	4
Print moves in and out of focus when reading	0	1	2	3	4
LIGHT SENSITIVITY					
Normal indoor lighting is uncomfortable – too much glare	0	1	2	3	4
Outdoor light too bright – have to use sunglasses	0	1	2	3	4
Indoors fluorescent lighting is bothersome or annoying	0	1	2	3	4
DRY EYES					
Eyes feel "dry" and sting	0	1	2	3	4
"Stare" into space without blinking	0	1	2	3	4
Have to rub the eyes a lot	0	1	2	3	4
DEPTH PERCEPTION					
Clumsiness / misjudge where objects really are	0	1	2	3	4
Lack of confidence walking / missing steps / stumbling	0	1	2	3	4
Poor handwriting (spacing, size, legibility)	0	1	2	3	4
PERIPHERAL VISION					
Side vision distorted / objects move or change position	0	1	2	3	4
What looks straight ahead--isn't always straight ahead	0	1	2	3	4
Avoid crowds / can't tolerate "visually-busy" places	0	1	2	3	4
READING					
Short attention span / easily distracted when reading	0	1	2	3	4
Difficulty / slowness with reading and writing	0	1	2	3	4
Poor reading comprehension / can't remember what was read	0	1	2	3	4
Confusion of words / skip words during reading	0	1	2	3	4
Lose place / have to use finger not to lose place when reading	0	1	2	3	4

BIVSS_28.item.clinical.use._[09/14_Hannu Laukkanen] Predictive score = ≥ 31 **total score for all 28-items:** _____

From: Laukkanen H, Scheiman M, Hayes JR. Brain Injury Vision Symptom Survey (BIVSS) Questionnaire. Optom Vis Sci 2017;94(1):43-50. doi:10.1097/OPX.0000000000000940.

APPENDIX 2

THE VISUAL/OCULAR MOTOR SCREENING (VOMS)

Vestibular/Ocular-Motor Screening (VOMS) for Concussion

Vestibular/Ocular Motor Test:	Not Tested	Headache 0-10	Dizziness 0-10	Nausea 0-10	Fogginess 0-10	Comments
BASELINE SYMPTOMS:	N/A					
Smooth Pursuits						
Saccades – Horizontal						
Saccades – Vertical						
Convergence (Near Point)						(Near Point in cm): Measure 1: _____ Measure 2: _____ Measure 3: _____
VOR – Horizontal						
VOR – Vertical						
Visual Motion Sensitivity Test						

Instructions:

Interpretation: This test is designed for use with subjects ages 9-40. When used with patients outside this age range, interpretation may vary. Abnormal findings or provocation of symptoms with any test may indicate dysfunction – and should trigger a referral to the appropriate health care professional for more detailed assessment and management.
Equipment: Tape measure (cm); Metronome; Target w/ 14 point font print.

Baseline Symptoms – Record: Headache, Dizziness, Nausea & Fogginess on 0-10 scale prior to beginning screening

- **Smooth Pursuits -** Test the ability to follow a slowly moving target. The patient and the examiner are seated. The examiner holds a fingertip at a distance of 3 ft. from the patient. The patient is instructed to maintain focus on the target as the examiner moves the target smoothly in the horizontal direction 1.5 ft. to the right and 1.5 ft. to the left of midline. One repetition is complete when the target moves back and forth to the starting position, and 2 repetitions are performed. The target should be moved at a rate requiring approximately 2 seconds to go fully from left to right and 2 seconds to go fully from right to left. The test is repeated with the examiner moving the target smoothly and slowly in the vertical direction 1.5 ft. above and 1.5 ft. below midline for 2 complete repetitions up and down. Again, the target should be moved at a rate requiring approximately 2 seconds to move the eyes fully upward and 2 seconds to move fully downward. Record: Headache, Dizziness, Nausea & Fogginess ratings after the test. (Figure 1)

- **Saccades** – Test the ability of the eyes to move quickly between targets. The patient and the examiner are seated.
  - **Horizontal Saccades**: The examiner holds two single points (fingertips) horizontally at a distance of 3 ft. from the patient, and 1.5 ft. to the right and 1.5 ft. to the left of midline so that the patient must gaze 30 degrees to left and 30 degrees to the right. Instruct the patient to move their eyes as quickly as possible from point to point. One repetition is complete when the eyes move back and forth to the starting position, and 10 repetitions are performed. Record: Headache, Dizziness, Nausea & Fogginess ratings after the test. (Figure 2)
  - **Vertical Saccades**: Repeat the test with 2 points held vertically at a distance of 3 ft. from the patient, and 1.5 feet above and 1.5 feet below midline so that the patient must gaze 30 degrees upward and 30 degrees downward. Instruct the patient to move their eyes as quickly as possible from point to point. One repetition is complete when the eyes move up and down to the starting position, and 10 repetitions are performed. Record: Headache, Dizziness, Nausea & Fogginess ratings after the test. (Figure 3)

- **Convergence** – Measure the ability to view a near target without double vision. The patient is seated and wearing corrective lenses (if needed). The examiner is seated front of the patient and observes their eye movement during this test. The patient focuses on a small target (approximately 14 point font size) at arm's length and slowly brings it toward the tip of their nose. The patient is instructed to stop moving the target when they see two distinct images or when the examiner observes an outward deviation of one eye. Blurring of the image is ignored. The distance in cm. between target and the tip of nose is measured and recorded. This is repeated a total of 3 times with measures recorded each time. Record: Headache, Dizziness, Nausea & Fogginess ratings after the test. Abnormal: Near Point of convergence ≥ 6 cm from the tip of the nose. (Figure 4)

- **Vestibular-Ocular Reflex (VOR) Test** – Assess the ability to stabilize vision as the head moves. The patient and the examiner are seated. The examiner holds a target of approximately 14 point font size in front of the patient in midline at a distance of 3 ft.
  - **Horizontal VOR Test**: The patient is asked to rotate their head horizontally while maintaining focus on the target. The head is moved at an amplitude of 20 degrees to each side and a metronome is used to ensure the speed of rotation is maintained at 180 beats/minute (one beat in each direction). One repetition is complete when the head moves back and forth to the starting position, and 10 repetitions are performed. Record: Headache, Dizziness, Nausea and Fogginess ratings 10 sec after the test is completed. (Figure 5)
  - **Vertical VOR Test**: The test is repeated with the patient moving their head vertically. The head is moved in an amplitude of 20 degrees up and 20 degrees down and a metronome is used to ensure the speed of movement is maintained at 180 beats/minute (one beat in each direction). One repetition is complete when the head moves up and down to the starting position, and 10 repetitions are performed. Record: Headache, Dizziness, Nausea and Fogginess ratings after the test. (Figure 6)

- **Visual Motion Sensitivity (VMS) Test –** Test visual motion sensitivity and the ability to inhibit vestibular-induced eye movements using vision. The patient stands with feet shoulder width apart, facing a busy area of the clinic. The examiner stands next to and slightly behind the patient, so that the patient is guarded but the movement can be performed freely. The patient holds arm outstretched and focuses on their thumb. Maintaining focus on their thumb, the patient rotates, together as a unit, their head, eyes and trunk at an amplitude of 80 degrees to the right and 80 degrees to the left. A metronome is used to ensure the speed of rotation is maintained at 50 beats/min (one beat in each direction). One repetition is complete when the trunk rotates back and forth to the starting position, and 5 repetitions are performed. Record: Headache, Dizziness, Nausea & Fogginess ratings after the test. (Figure 7)

From: Mucha A, Collins MW, Elbin RJ, et al. A Brief Vestibular/Ocular Motor Screening (VOMS) assessment to evaluate concussions: preliminary findings. Am J Sports Med 2014;42(10):2479-2486. doi:10.1177/0363546514543775.