Article: Clinical Implications of the Center of Balance for a Veteran with Traumatic Brain Injury

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ABSTRACT

Background: It is known that traumatic brain injury (TBI), even of the mild variety, can cause diffuse multisystem neurological damage. Coordination of sensory input from the visual, vestibular and somatosensory pathways is important to obtain proper balance and stabilization in the visual environment. This coordination of systems is potentially disrupted in TBI leading to visual symptoms and complaints of dizziness and imbalance. The Center of Balance (COB) at the Northport Veterans Affairs Medical Center (VAMC) is an interprofessional clinic specifically designed for patients with such complaints. An evaluation entails examination by an optometrist, audiologist and physical therapist and is concluded with a comprehensive rehabilitative treatment plan. The clinical construct will be described and a case report will be presented to demonstrate this unique model.

Case Report: A combat veteran with a history of a gunshot wound to the skull, blunt force head trauma and exposure to multiple explosions presented with complaints of difficulty reading and recent onset dizziness. After thorough evaluation in the COB, the patient was diagnosed with and treated for severe oculomotor dysfunction and benign paroxysmal positional vertigo.

Conclusion: Vision therapy was able to provide a successful outcome via improvement of oculomotor efficiency and control. Physical therapy intervention was able to address the benign paroxysmal positional vertigo. The specific evaluation and management as pertains to the aforementioned diagnoses, as well as the importance of an interprofessional rehabilitative approach, will be outlined.

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INTRODUCTION

TBI is an acute brain injury resulting from an external force. Active military personnel are at increased risk of TBI incidents. According to data from the Department of Defense in 2012, over 250,000 soldiers deployed in Iraq and Afghanistan were diagnosed with TBI. Among veterans who have suffered TBI, blast injury has become the most prominent cause. Blast injury is the hallmark of returning soldiers involved in Operation Iraqi Freedom (OIF) and
Operation Enduring Freedom (OEF) due to increased presence of improvised explosive devices (IEDs). Such devices cause both direct damage to those within the vicinity, and also indirect damage via percussive shockwave forces extending throughout a wider diameter. Shock waves radiate through fluid of the body and brain; the extent of damage depending on the distance from detonation, composition of the explosive and whether the explosion was contained or open. Other causes of combat related TBI are gunshot wounds, motor vehicle accidents, collisions and falls.

The concepts of primary and secondary brain injuries are essential when considering the evaluation and treatment of post-TBI patients. Primary injury is caused directly by the mechanical insult. The violent jolt motion experienced during head trauma causes twisting and stretching of axons. This can lead to axonal shearing and resultant damage to neuronal pathways. Other direct injuries such as tissue swelling, skull fractures and/or hematomas would also be classified as primary injuries. Following the initial injury, a cascade of metabolic changes to the axons, termed secondary injury, occurs. The changes lead to subtle alteration in structure and function, providing the underlying basis of patient symptoms. Post-concussion syndrome is a specific set of symptoms, which may occur weeks to months after a concussion, and includes: impaired memory, difficulty concentrating, mood swings, personality changes, fatigue, dizziness, headaches and insomnia.

In post-TBI patients, secondary injury to the visual pathway can lead to impairment of basic tracking, scanning, accommodation, vergence and visual processing skills. This causes symptoms such as headache, diplopia, asthenopia and/or defocus. The summation of these symptoms has been termed post-trauma vision syndrome. While the optometrist may be keen to honing in on visual pathway deficits, it is important to consider other systems, which if damaged can present with similar symptoms to or exacerbate the visual ones.

The Vestibulo-ocular Reflex

The vestibular system is strongly correlated with the visual system. The vestibulo-ocular reflex (VOR) is responsible for stabilizing the retinal image while a patient’s head is in motion. For this to occur, an equal and opposite eye-head movement combination is required. The cascade of events begins with motion detection by the otoliths in the semicircular canals. This is followed by excitation of the vestibular and abducens nerve on the side of the direction of motion. Neuronal signals are then sent to both the lateral rectus muscle of the eye contralateral to the motion direction and the medial longitudinal fasciculus (MLF) of the eye ipsilateral to the motion direction. From the MLF the oculomotor nerve excites the medial rectus of the eye ipsilateral to the motion direction. This results in a compensatory eye movement thereby stabilizing the retinal image and maintaining clear vision. Due to a mismatch of this eye-head coordination, a patient with VOR dysfunction may complain of oscillopsia, dizziness and balance issues.

Somatosensory Components of Balance

The musculoskeletal system may also help or hinder the visual system. According to the American Physical Therapy Association, balance involves coordination of temporal spatial patterns and postural equilibrium reflexes, both of which involve concurrent interpretation of visual and muscular cues. Additional considerations in maintaining balance are muscle strength and complex somatosensory and central nervous system feedback loops. A patient with dysfunction of this nature may complain of dizziness, imbalance or difficulty with depth perception.

The Center of Balance

The aforementioned relationships between the visual, vestibular and somatosensory systems provide the foundation for the COB clinic at the Northport VAMC. Dr. Patrick Masone established this interprofessional clinic while acting as chief
of audiology and speech pathology services at Northport VAMC in 2007. Dr. Masone attended the Pennsylvania College of Optometry School of Audiology where he was exposed to an optometry school on the same campus. While learning and working amongst his optometrist colleagues, he came to appreciate the interplay of these systems and sought to utilize this relationship to improve the rehabilitation process for veterans.

Evaluation in the COB consists of three components: optometry, physical therapy and audiology. After all individual evaluations are completed, the team of professionals discusses the results and creates a comprehensive rehabilitation plan. The plan is then discussed with the patient and the patient’s referring physical medicine and rehabilitation physician. The COB was not only the first of its kind at a VA hospital but was the first to exist in the United States as a whole. It now serves as a prototype for other interprofessional clinics nationwide to allow more thorough evaluation and treatment of patients with multi-system injuries.

It is important to note that this clinic is in no way limited to those patients who have suffered TBI. TBI is merely one cause of visual symptoms coupled with complaints of dizziness that has been commonly encountered amongst veterans at this site and therefore was chosen for discussion.

**COB: Role of the Optometrist**

**Quantifying Symptoms**

With post-TBI patients often characterized by symptoms much worse than physical signs, it is imperative to perform a symptom survey. This allows the practitioner to firstly focus the exam and secondarily to tailor the management plan. For vision rehabilitation, the symptom survey has its maximum value in tracking progress and guiding goals. A sample will be provided as part of the case report.

**Sensorimotor Evaluation**

After completion of a comprehensive ocular health assessment with refractive analysis and dilated fundus exam, the sensorimotor testing can begin. An evaluation of ocular motilities should be performed to test for cranial nerve palsy or paresis, range of motion, ease of movement and comitancy. Some noteworthy features during testing include qualitative differences between the two eyes or between ductions and versions, quality of movement (smooth, jerky), motor overflow, head and body posture, facial expression, and presence or absence of nystagmus. Subsequent evaluation of saccades, fixation and pursuit eye movements should be performed. Methods of testing include the Developmental Eye Movement Test, King-Devick Test, Visagraph eye-movement tracking system, NSUCO Oculomotor Test and free-space observation.

Abnormal vergence and accommodation may also result from TBI. High yield tests to screen for these conditions include near point of convergence, positive/negative relative accommodation, accommodative amplitude and accommodative facility. Testing of visual information processing and perceptual aspects pertaining to reading should also be performed. Additional testing in this realm may investigate visual memory, speed of processing, sequential memory and audio-visual and visuo-motor integration.

**Optometric Testing of the VOR**

It is important to test post-TBI patients with visual symptoms for vestibulo-ocular reflex deficits. Two high-yield methods will be discussed, both of which can be performed chair-side in an optometrist’s office. The first test, dynamic visual acuity, entails having the patient read the acuity chart binocularly while the examiner turns the patient’s head side-to-side at a rate of approximately one turn per second. If there is no deficit, the patient should be able to read a line of letters within two lines of their static best-corrected binocular acuity.
For example, if the best-corrected visual acuity is 20/20, the patient should have no difficulty reading the 20/30 line with head motion. The patient and doctor positioning for this test can be observed in image 1.

Image 1: Patient and doctor positioning for dynamic visual acuity test

The second, the head thrust test, entails having the subject view a straight ahead target, such as the practitioner’s nose, while the practitioner slowly turns the patient’s chin toward one side then unexpectedly snaps it back to face forward. This is to be performed toward the right and the left while observing fixation maintenance and re-fixation saccades. A normal response is continuous fixation; an abnormal response is an overshoot saccade followed by a re-fixation of the target once the head is snapped. The patient and doctor positioning for this test can be observed in image 2.

Image 2: Patient and doctor positioning for head thrust test

Spectacle Correction and Tinting

Amongst a sample of post-mild TBI patients (from 2009-2011), more than half presented with photosensitivity as the most prominent visual complaint. Fortunately, optometrists are often able to address this with proper spectacle tinting. While tint selection is partially based on patient preference, a few options that have proven successful include blue, grey and amber tints. Blue tints have been shown to accentuate abilities of the magno-cellular processing system, which is prone to damage during brain injury, and facilitate reading ability. Grey tints are useful for general photosensitivity and light grey shades help to reduce indoor glare from overhead fluorescent lights. Amber tints aid in improving contrast of reading material and visual comfort. For indoor tints, 35% is usually sufficient, while an outdoor tint should be approximately 85%.

In addition to tinting, correction of minimal residual refractive error is imperative; this includes low amounts of hyperopia and astigmatism. In a fragile visual system even the slightest defocus, which can typically be compensated for in a normal patient, becomes an additional factor impeding proper visual input. In patients with persistent balance issues, single vision distance and near spectacles are preferable over progressive addition lenses (PALs). The peripheral distortion in PALs may exacerbate symptoms of disequilibrium and hinder safe mobility. Providing an image of optimal clarity should always be the first step. Once this has been achieved, rehabilitative vision therapy is considered if indicated.

Rehabilitative Vision Therapy

The second most common visual complaint of post-TBI patients is difficulty reading. If a visual skills deficit is identified as contributory, a course of rehabilitative vision therapy is indicated. The goal of such a program is to improve sensory and motor control over the visual system, thereby improving overall reading efficiency, reading speed and visual comfort.
Vision therapy programs for post-TBI patients must be tailored to meet the unique needs of this population. To avoid frustration and visual discomfort, encourage the patient to take breaks between exercises. Utilize free space exercises rather than in-instrument activities to improve feelings of stability in the environment. These patients also tend to experience hypersensitivity to surrounding stimuli such as noise or movement. Early on, avoid an atmosphere with extraneous sensory stimuli as to not overwhelm the patient. Also, explain techniques slowly and make slow changes with equipment, such as when switching lenses or prisms. If the patient suffers from photosensitivity, be sure to adjust lights accordingly and ensure the patient is wearing an appropriate tint during therapy.

The therapy endpoint is when oculomotor skills and associated factors such as speed, accuracy, and motor overflow, are normalized for the patient’s age. It has been demonstrated that post-TBI patients experience a decrease in overall reading-related visual symptoms after a course of rehabilitative vision therapy. This includes measurable increases in reading ability, comprehension, concentration and overall reading strategy.\(^8\) Suggested therapy techniques for reading-eye movements include Michigan Letter Tracking, counting vertical lines along a horizontal row, and visual search and scan exercises.\(^10\) An in-depth review of mild TBI patient records pre and post-oculomotor based vision therapy by Ciuffreda showed increased reading rate from an average of 137 words per minute to 177 words per minute. The same study measured significant improvements in objective fixation, saccade and pursuit eye movements. The pre and post-visual symptom surveys also exhibited marked improvements. Most importantly, patients reported carry-over from improved visual skills to activities of daily living.\(^8\)

**COB: Role of the Audiologist**

The audiologist’s evaluation consists of hearing, auditory processing, neuronal auditory pathway and inner ear testing.\(^14\) For a patient complaining of dizziness, differentials include: infection, Meniere’s disease, vestibular dysfunction, brain injury or medication side effects. Two important tests performed as part of this exam are electroneystagmography (ENG) and videonystagmography (VNG). ENG records nystagmus while the patient is maneuvered into various positions, as well as while the patient is physically experiencing symptoms.\(^15\) VNG creates a video recording of the nystagmus in various positions based on an eye-tracking system worn by the patient during testing.\(^16\) This portion of the exam also includes caloric testing to evaluate the VOR. During caloric testing, cold and warm water or air is separately exposed to the external auditory canals. The different temperatures effect placement of endolymph within the semicircular canals and cause a vestibular system response of nystagmus. The expected finding of the cold-water test is to note eye movement toward the ipsilateral side and nystagmus toward the opposite side of the tested ear. This is because cold temperature causes endolymph to slide downward within the canal simulating a head rotation toward the contralateral side. Warm water causes the opposite response; eye movement toward the contralateral side with nystagmus toward the ipsilateral side due to endolymph rising higher in the canal, simulating head rotation toward the ipsilateral side.\(^17\)

**COB: Role of the Physical Therapist**

The physical therapist’s evaluation consists of postural alignment, static and dynamic stability, balance and motor system functioning tests.\(^6\) The physical therapist repeats the dynamic visual acuity and head thrust tests, which are then compared to the optometrist’s results. Computerized dynamic posturography (CDP) is performed which entails the patient being placed in a balance simulator. Balance and visual demands are altered to create a sensory mismatch. The patient responses and ability to stabilize are recorded through floor sensors and
timers. This information is useful in diagnosing pathology of the peripheral and central nervous system. The CDP simulator can be viewed in image 3.

**CASE REPORT**

To aid in visualizing this clinical model, a case of a 69-year-old white male who presented for an optometric exam as part of a COB evaluation will be discussed. His chief complaints were difficulty reading for periods longer than 15 minutes, difficulty concentrating while reading and having to re-read text. Additionally, he experienced general light sensitivity to overhead fluorescent lighting, which he felt was further impeding his general visual comfort. He also complained of recent onset bouts of dizziness, which lasted for about one minute each morning and began six months ago.

Patient medical history consisted of post-traumatic stress disorder, depression, sleep apnea and hypertension. His medications included clonazepam, trazadone and nebivolol and his personal and family ocular histories were unremarkable. Best-corrected visual acuity for the right eye and left eye was 20/20. His ocular health findings including dilated fundus exam were within normal limits. As is customary when working with veterans, a careful history of head trauma and combat injuries was taken. This patient had a history of a gunshot wound to the left temporal area about 25 years ago while in military service. He also had been in the vicinity of two explosions, though he did not suffer direct damage. He also reported that before serving in the army he had experienced multiple concussions from blunt head trauma while playing baseball. Unfortunately this patient was followed by a private neurologist outside of the VAMC and his imaging was not available for review.

The symptom survey created for use at the Northport VAMC, with the patient’s responses, can be viewed in Figure 1. Generally a score of greater than 20 is considered significant, however, this has not been statistically quantified.

During the sensorimotor exam, cover test revealed ortho-phoria at distance and a small exo-phoria at near. Ocular motilities, including versions and ductions, were normal and without restrictions. Binocular assessment in the phoropter demonstrated adequate fusional vergence ranges at both distance and near. Near point of convergence was normal, along with appreciation of physiologic diplopia and no deterioration on repeated testing. Vectogram testing with the clown target was performed and demonstrated expected fusional convergence and divergence abilities. The patient had a good appreciation of depth, localization of the target and the “Small-In, Large-Out” effect. He did not exhibit any suppression during testing.

Oculomotor testing did demonstrate several abnormalities consistent with the chief complaint. During fixation testing, the patient...
**Figure 1**: Traumatic Brain Injury/Acquired Brain Injury Symptom Survey at initial consultation

Directions: Please consider each symptom and select the corresponding number following the key below:

0 = Symptom Not Present  
1 = Symptom Minimally Present  
2 = Symptom Moderately present  
3 = Symptom Severely Present

**SYMPTOM (S):**  
Emergent Visual Conditions:

- Flashes of light: .................................................. 0  
- Floaters in field of view: ...................................... 0  
- Restricted field of vision: .................................... 0  
- “Curtain” billowing into field of view: ...................... 0

Urgent Visual Conditions

- Inability to completely close eyes: .......................... 0  
- Difficulty moving or turning eyes: ......................... 0  
- Pain with movement of the eyes: ......................... 0  
- Pain in or around eyes: ........................................ 0  
- Wandering eye: .................................................. 0  
- Double vision: .................................................... 0

TBI/ABI Optometric Vision Rehabilitation Conditions:

- Blurred Vision, Distance viewing: ......................... 0  
- Blurred Vision, Near viewing: ............................. 0  
- Slow to shift focus, near to far to near: ................... 0  
- Difficulty taking notes: ........................................ 0  
- Pulling or tugging sensation around the eyes: .......... 0

- Face or head turn: .................................................. 0  
- Head tilt: ............................................................ 0  
- Covering, closing one eye: .................................. 0

- Disorientation: .................................................... 0  
- Bothered by movement in spatial world: ................. 3  
- Bothered by noises in environment: ...................... 3  
- Light sensitivity: .................................................. 2

- Discomfort while reading: .................................... 3  
- Unable to sustain near work/reading for adequate periods: 3  
- General fatigue while reading: ............................ 3  
- Loss of place while reading: ............................ 3  
- Eyes get tired while reading: ............................ 3  
- Headaches: .......................................................... 0

- Easily distracted: ............................................... 3  
- Decreased attention span: ................................... 3  
- Reduced concentration ability: ............................ 3  
- Difficulty remembering what has been read: ........ 2

- Loss of balance: ................................................. 2  
- Poor eye-hand coordination: ................................ 0  
- Poor handwriting: ............................................... 0  
- Poor posture: ..................................................... 0

- Dizziness: ........................................................... 2  
- Poor coordination: .............................................. 1  
- Clumsiness: ........................................................ 1

**TOTAL:** 40

The patient completed 16 sessions of vision therapy and at that point a sensorimotor re-evaluation was performed. He rarely noticed the previously reported reading-related symptoms and was eager to finish his therapy program. Evaluation testing showed improved objective findings on all fronts. Saccade and pursuit testing had multiple fixation losses with each eye separately while fixating a near target for 10 seconds. Binocular testing was slightly improved but the patient reported subjective difficulty when tested both monocularly and binocularly. Free-space saccadic testing was performed and multiple undershoots and re-fixations on horizontal, vertical, and oblique left/right testing were present. There was slight motor-overflow observed during testing and the patient squinted his eyes to assist in concentrating. On the Developmental Eye Movement Test the patient scored in the 33rd percentile on the vertical test and the 4th percentile on the horizontal test; he had no errors on either test.\(^{20}\) These results demonstrated an oculomotor deficit. Both VOR tests, as discussed earlier, were performed on the patient and yielded normal results.

To address photosensitivity with indoor fluorescent lighting while reading, a trial of tints was performed. The patient preferred a light blue tint of 15% rather than equal tints of grey or brown. After discussing options with the patient, he preferred the tint only in his reading glasses; separate non-tinted distance and tinted reading glasses were ordered.

Based on the exam findings, approximately 20 sessions of weekly rehabilitative vision therapy was recommended. The patient was very motivated, making him a good therapy candidate, and was asked to return in one week for the first session. He was taught the Hart Chart saccade technique and the thumb rotation pursuit technique to perform at home three-to-four times during the week. Sample progressions of the Hart Chart exercise for saccades and the thumb rotation technique for pursuits are provided in Figures 2 and 3 respectively.

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showed normalized abilities and the patient could fixate for 10 seconds without deviation both monocularly and binocularly. The results of the Developmental Eye Movement Test improved to 54th percentile on the vertical test and 84th percentile on the horizontal test; once again the patient made no errors. The results were no longer suggestive of an oculomotor deficit. Most importantly, the symptom survey score of the patient at this time was 7 and he was noticing carry over of his improvements to his activities of daily life. He now enjoyed reading the morning newspaper, whereas before remediation of his oculomotor issues, he had avoided reading tasks altogether. All findings were discussed with the patient and home therapy techniques were reviewed. It was recommended for the patient to continue home-based therapy techniques two-to-three times per week and return in two months for a re-evaluation to ensure stability of his visual skills.

Following the initial audiology and physical therapy evaluations, the patient was diagnosed with benign paroxysmal positional vertigo, a common condition where the crystals in the inner ear become dislodged. This causes quick bouts of extreme vertigo after rapid head movements or position changes. Canalith reposition therapy, specifically the Dix Hallpike maneuver, is used in remediation of this condition. This entails a pattern of head and neck maneuvers to guide the crystals back into position. An audiologist or physical therapist can administer the treatment; in this case, the physical therapist performed it. In a majority of patients, a single treatment will alleviate symptoms, however, in this particular patient a course of three treatments over a month span was indicated and successful.

**Interprofessional Approach**

With the damage from TBI usually encompassing numerous neurologic areas beyond the visual system, it is important to direct our patients to appropriate members of the multidisciplinary team. The first step in this process is to ensure the patient has had an evaluation by a physiatrist, also referred to as a physical medicine and rehabilitation physician. This type of practitioner will compose a rehabilitative plan for the patient to address all systems involved. This will encompass medical, social, emotional and vocational aspects. Referral to a psychiatrist or psychologist may be warranted to treat post-traumatic stress disorder, depression, and/or anxiety. While it is likely the patient would have had a complete neurologic examination prior to entering an optometrist’s office, if migraines, chronic pain or suspected cranial nerve damage are found, further consultation should be pursued. If cognitive impairments are present, a neuropsychologist can perform thorough testing to differentiate between causality due to

<table>
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<tr>
<th>Figure 2: Sample progression of Hart Chart therapy technique</th>
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<td><strong>Instructions:</strong> Letter chart situated at patient eye level about 6 feet away, patient follows the exercises listed below.</td>
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| Early phase | Monocular saccades from first letter of first line to last letter of first line. This is continued throughout chart then repeated with second and second to last columns and third and third to last. |
| Intermediate phase | Repeat the above binocularly. Add metronome to improve rhythm and speed. |
| Late phase | Add balance board for proprioceptive feedback. Try patterns such as every other, every third letter or reading on a diagonal. |

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<th>Figure 3: Sample progression of thumb rotation therapy technique</th>
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<td><strong>Instructions:</strong> Patient maintains a “thumbs up” position with one hand while following thumb during the following tasks</td>
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| Early phase | Monocular, “+” then “x” pattern with slow horizontal and vertical movements extending approximately 12 inches, performed in front of a blank background |
| Intermediate phase | Small circular rotations spiraling outward in clockwise then counter clockwise directions (approximately 1 inch to 6 inches) |
| Late phase | Patient turns head side-to-side and up-and-down while focused on thumb to incorporate vestibulo-ocular reflex, add balance board for proprioceptive feedback or metronome for speed |
traumatic neurologic injury versus psychological mechanisms.

Additionally, overall patient comfort and quality of life can often be improved with the assistance of speech, occupational and physical therapy. A speech pathologist may improve speech and language deficits, thereby improving social communication and interaction. For patients experiencing dizziness, disequilibrium and instability, a physical therapist may successfully address these complaints. The physical therapist can compose a regimen of strengthening exercises to improve patient stability when navigating his/her environment; this can improve comfort and confidence in resumption of normal daily activities. If vestibular dysfunction or inner ear disorders are suspected, an evaluation with an audiologist would be imperative as well. The disciplines of audiology and physical therapy may work in conjunction with a vestibular therapist to remediate a mixed mechanism issue. Lastly, occupational therapy can assist in resumption of normal daily routines by improving organization and planning of specific tasks. Generally these therapists focus on fine-motor tasks, such as reading and writing; the organization and planning skill can then be applied and used in other capacities of the patient’s life.

Addressing visual skills deficits with vision therapy may additionally facilitate a patient’s overall rehabilitation by enhancing progress on parallel disciplinary fronts. For example, strengthening spatial and depth awareness with vision therapy may translate into greater therapeutic benefit in physical or vestibular therapy. It may also enhance organization development in occupational therapy, and in conjunction with certain psychology disciplines, improve visual attention, visual memory and information processing.

CONCLUSION

The neurological consequences of TBI are becoming more recognized, necessitating the development of more accurate and extensive rehabilitation. Our goal as optometrists is to primarily focus on the aspects pertaining to the visual pathway and assist patients in the healing process. Deficits of visual skills and/or visual processing, including oculomotor dysfunction as outlined in the case report, can generate significant patient complaints. As these deficits manifest as difficulty reading, it is becoming increasingly common for patients to seek evaluation and treatment from behavioral optometrists. Patient management may include rehabilitative vision therapy, in conjunction with customized spectacles and tints. It is essential to remember the power of collaboration amongst rehabilitative professions; this will ensure thorough evaluation of all body systems potentially impacted by TBI and provide the patient with the greatest opportunity for success. While the Northport VAMC is fortunate to have a specialty clinic for this purpose, it is likely practitioners in other settings do not have access to such a resource. It is therefore imperative to establish a network for interprofessional referrals, consisting of motivated rehabilitative providers. While not as convenient as a clinic housed under a single roof, it can provide patients with access to all of the same specialists and the increased probability of success that results from such collaboration.

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