Oculo-Visual Evaluation of the Patient with Traumatic Brain Injury

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ABSTRACT

Traumatic brain injury is a term used to group conditions caused by a disruption in normal brain function secondary to an external source. Traumatic brain injury can range from mild to severe. These patients can be symptomatic with subtle to major physiological changes unapparent upon imaging. Some of the more common symptoms of traumatic brain injury include loss of consciousness, loss of memory before or after the injury, an alteration in mental state at the time of the accident or a focal neurological deficit. Frequent visual symptoms associated with TBI include unexplained vision changes, photosensitivity, and motion hypersensitivity, as well as decreased visual processing speed, which can make this population difficult and time-consuming to examine. The patient's symptoms are often dismissed as psychological, secondary to the neurological disorders associated with the injury. This paper discusses modified examination procedures for symptomatic patients with traumatic brain injury. This paper has been written to encourage optometrists to become members of the rehabilitation team so that these patients can receive the comprehensive care necessary for maximal recovery.

Keywords: ABI, acquired brain injury, head trauma, TBI, traumatic brain injury, vision rehabilitation

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Introduction

Traumatic brain injury (TBI) is a term used to group conditions caused by a physiologic disruption in normal brain function secondary to an external insult to the brain or neck.[1] TBI can range from mild to severe. These patients can be symptomatic with subtle to major physiological changes not apparent upon imaging. Over 5 million Americans (about 2% of the population) are living with a disability secondary to TBI that resulted in hospitalization. This is equal to 1.4 million Americans per year suffering from TBI.[2,3] TBI may be linked to a variety of etiologies. Motor vehicle accidents are responsible for approximately half of all reported brain injuries.[3] Teenagers are most frequently affected, with males three times more likely to have TBI than females.[3] The second most common cause of TBI is slip-and-falls among the elderly, with an equal predilection between males and females.[3] TBI is more common noted among those who serve in the military even during times of peace. According to the Department of Defense, over 1800 soldiers returning from the war in Iraq have sustained neurosensory consequences secondary to TBI, which have impaired their behavior and ability to work.[4] Medical technology advances and a decline in mortality also have contributed to an increase in the prevalence of TBI, especially among the elderly and military personnel.[4]

According to recent literature, the number of patients with TBI is actually higher than reported, as only those who seek medical attention through a hospital are documented. Traditionally, this consists of only moderate and severe TBI patients. Many mild TBI patients who may have had a brief loss of consciousness or a mild concussion, do not always seek medical attention.

When a patient is hospitalized after sustaining a TBI, there is little time or consideration given to rehabilitation. Often, it is only after these patients are discharged that the need for multiple outpatient therapies becomes apparent. Patients can be symptomatic with or without any physical signs of injury. Accordingly, it is often difficult to differentiate between physical and psychological deficits. The distinction is often compounded by the limitation of current imaging technology to demonstrate the subtle physiological changes associated with a mild TBI.

Optometrists have examination and therapy procedures that assist in rehabilitating the visual sensory motor deficits caused by TBI.[5] As part of an interdisciplinary team, optometrists are also prepared to ensure that patients are visually prepared for other rehabilitative therapies. This paper outlines examination procedures for TBI patients. (Table 1) It also encourages optometrists to join the rehabilitation team so these patients can receive the comprehensive eye and vision care necessary for maximal recovery.

General Considerations

The visual symptoms associated with TBI may be difficult to diagnose and treat since each case can present differently. Some visual symptoms of TBI include post-traumatic unexplained vision changes and/or decreased visual processing speed. This decreased visual processing speed can make this population difficult and time consuming to examine. Other possible characteristics include Post-Trauma Vision Syndrome (PTVS)[6] which is characterized by low blink rate, diplopia, poor fixation, and oculomotor dysfunction. PTVS is also associated with accommodative dysfunction, spatial disorientation, convergence insufficiency and poor visual memory, as well as associated neuromotor difficulties involving balance, coordination and posture.

Because patients with TBI might be hypersensitive to many types of stimulation, including noise levels, motion, light, and detailed patterns; optometrists should pay close attention to the environment in which the examination is conducted. For example, these patients appreciate a separate waiting area and examination rooms that are relatively plain and free from unnecessary noise, fluorescent lighting and motion. Waiting and examination areas for TBI patients should also be handicap accessible for patients who use a wheelchair, walker, cane or other similar device.

Even with environmental accommodations, patients with TBI often require at least three sessions for an initial comprehensive examination due to reduced endurance and impaired information processing. In the first session, practitioners should focus on a thorough case history, refraction, binocular assessment, pupils and anterior/posterior segment ocular health. The second examination should include visual fields to assess the visual pathway. Depending on the patient's stamina, visual processing and perceptual assessment may require a third examination. A resource of information for visual processing and perceptual assessment is *Vision, Perception, and Cognition: A Manual for the Evaluation and Treatment of the Adult with Acquired Brain Injury by Barbara Zoltan*.[7] This comprehensive examination structure will help set up an appropriate framework to incorporate the modified examination procedures for the patient with TBI.

Table 1. Modified Examination Procedures for Traumatic Brain Injury Patients.

Visual Acuity	Snellen, Pelli-Robson, Tumbling E
Retinoscopy/Refractions	Lens racks
Pupils	Size in dim and bright illumination Reactivity Accommodative response Relative afferent pupillary defect
Ocular Health	Red-free filter for comfort Dilated fundus exam mandatory
Visual Field	Humphrey Visual Field SS 30-2, or 76 pt 3 zone
Ocular Motilities	Developmental Eye Movement test Visagraph Ductions/ Versions
Accommodation	Facility (+/- 2.00 for 1 min) Minus lens to blur Monocular Estimate Method
Binocular assessment	Free space prisms Stereopsis

Examination procedures

Case History

A TBI patient's case history can be quite extensive and require additional time. Information about the injury must be considered. It is imperative to ask if there was a loss of consciousness and if so, for how long. The consideration of consciousness indicates the severity of damage from oxygen deprivation to the brain. One thing that might appear in TBI-related medical records is a Glasgow certification score. The Glasgow classification system is used in the hospital setting to determine the severity of brain damage incurred at the time of injury.[8] (Table 2) This rating system is based on motor, verbal and eye responses with five points given for each response. Although a patient's injury may have been classified as severe at the time of injury, a full recovery is still possible.

Table 2. Glasgow Classification System of Brain Injury[9]

<7	Coma
<8	Severe
9-12	Moderate
>13	Mild

Over time, patients may adapt and compensate for sensorimotor deficits, including visual deficits. It is helpful to ask about initial symptoms that immediately followed the accident, as well as current complaints. Some frequently encountered symptoms include photosensitivity, shimmering vision, difficulty focusing, and headaches, as well as dizziness/imbalance, double vision and visual field loss.[9]

Information (including history and physical examination, discharge summary, computed tomography, and magnetic resonance imaging reports, etc.) needs to be obtained from the interdisciplinary team of providers, including physiatrists (physicians who specialize in physical medicine and rehabilitation), neurologists, psychiatrists, psychologists, occupational therapists, speech therapists, physical therapists and caregivers. Neuro-psychological testing, neurological imaging and serological testing are an important part of the documentation in the case history of these patients to ensure they are receiving proper follow-up care. Loss of memory can hinder these patients in providing this information. For this reason, it is beneficial if most of the pertinent case history is obtained from a written survey filled out prior to the examination with assistance from a family member or friend. (Appendix 1)

Visual Acuity

Many patients with TBI have reduced visual acuity (VA), especially at near as a result of their injury. There are many reasons for reduced VA in this population, including physical ocular injury, sensory-motor deficits (accommodation, binocular vision) and neurological issues.

Initially, Snellen acuities are an essential measurement. It is important for documentation purposes to use a standardized chart because these patients are often involved in litigation. However, clinically, Snellen acuity does not give additional details about hypersensitivity to contrast and brightness which is a common issue among TBI patients. The Vistech, CSV-1000 or Pelli-Robson charts are examples of charts that test for contrast sensitivity. (Figure 1) They give better insight into subtle changes in a patient's vision, for instance contrast sensitivity testing is a more specific way to evaluate a person's ability to detect and recognize faces and objects when Snellen acuity is normal.

Retinoscopy and Refractive Status

A thorough refractive assessment is an essential component of patient evaluation and management. In many cases, refractive status changes after an accident. An appropriate refraction can maximize acuity in many cases. Refractive methods should be adapted according to a patient's needs. Verbal and cognitive problems, such as aphasia (inability to speak), visual agnosia (loss of ability to recognize objects, person, sounds, shapes, or smells) and/or memory loss may pose a challenge.[7, 10] For example; a patient might recite the alphabet to remember a letter seen on the chart. Using letters at the beginning of the alphabet or tumbling E's may decrease examination time for this type of patient. The clinician will need to work efficiently and to rely on objective testing results. Handheld lens racks make the task more comfortable

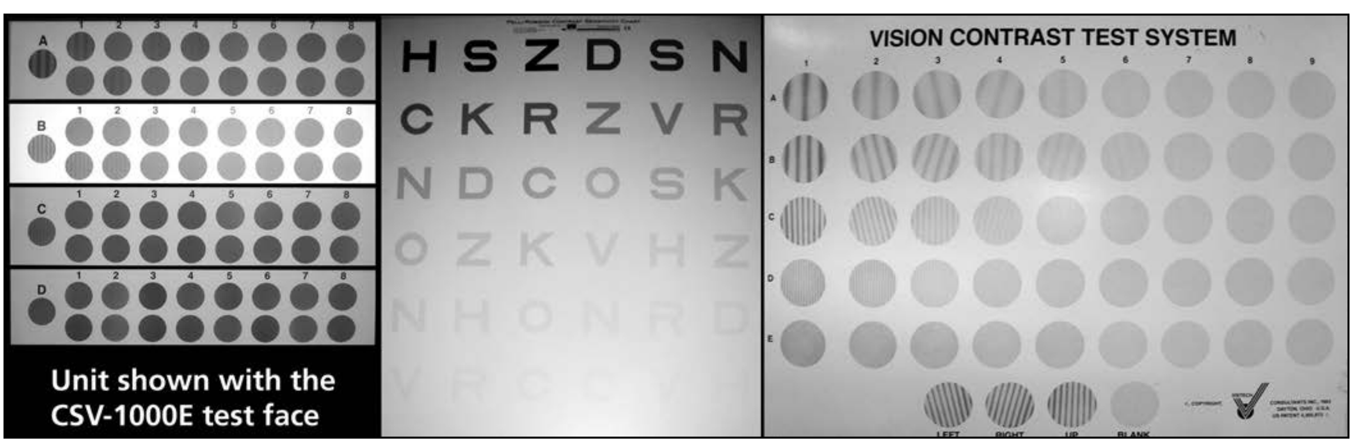

Figure 1: *Three examples of constrast sensitivity charts from left to right: CSV 1000, Pelli-Robson, and the Vistech charts.*

for the patient and easier for the doctor to monitor the patient's posture.

The patient with TBI should have a trial frame refraction instead of using a phoropter. This allows for an objective view of ocular and body posture. Sometimes, the patient may show improvement with low amounts of plus or minus lenses. For example, a quarter of a diopter of plus may not be prescribed for the average patient but in this population, it might make viewing more comfortable without a discernable improvement in VA.

Pupils

Size of the pupils should be measured in both bright and dim illumination. The reactivity to light and whether there is a relative afferent pupillary defect should also be noted. Specific pupillary anomalies which can induce photosensitivity include spasm of the near reflex, springing pupil (a benign episodic pupillary mydriasis) , anisocoria, traumatic mydriasis and a relative afferent pupillary defect. Side effects of medications, such as changes in pupil size and reactivity can lead to blurred vision, loss of accommodation and increased photosensitivity. Han et al. recently reported in a retrospective analysis of individuals with TBI that the four most common types of medications taken by patients with TBI were anti-anxiety/antidepressants (42.5%), anticonvulsants (26.9%), opiate/combination analgesics (23.8%) and cardiac/antihypertensives (23.1%). It was suggested that the side effects of these medications may have a relationship to the visual symptoms noted by patients with TBI . Specifically, symptoms of photosensitivity, dry eye, or poor stereopsis were found more frequently in patients taking certain medications, suggesting that the symptoms may be a drug induced side effect.[11]

Tinting Considerations

Depending upon symptomology, it might be necessary to consider tinted lenses for your patient's visual comfort. Hypersensitivity to detail, motion and brightness is reduced by prescribing tints. Low to high amounts of tints in grey or brown are prescribed for different settings including outdoor sunlight or fluorescent lighting in the grocery store and workplace. Tint percentages should be trial framed for reading purposes and use in fluorescent lighting. Light tints such as 10% and 15% can be used to decrease the contrast between white paper and black text, making a softer viewing surface. Also, using off-white paper for reading text can have a similar effect.

Higher degrees of tint, such as 50% and 75%, can be used for filtering out fluorescent lighting or sunlight. Recommending something as simple as a large brimmed hat that blocks sunlight and decreases visual stimuli may give the patient with TBI symptom relief.

Ocular Health

The ocular health assessment is a primary aspect of the examination. Special attention should be focused on those structures that are more vulnerable to injury from trauma. For example, the anterior segment should be assessed for foreign bodies, inflammation or the presence of blood.

The iris and anterior chamber angles of the patient should be examined via gonioscopy to rule out angle recession in cases of blunt trauma. A dilated fundus examination is also important to determine any damage to the optic nerve, macula, and retina.

When assessing damage, keep in mind that the optic nerve is vulnerable to optic neuropathy even in mild TBI. The structure of the optic nerve is made up of four zones: the optic zone, intraorbital zone, intracanalicular zone and the intracranial zone. All zones are surrounded by bony structure. McCann and Seiff make several points regarding optic neuropathy and damage to the optic nerve structure:

1) The bony structure narrows within the intracanalicular zone making the optic nerve tissue, especially the superior portion, vulnerable to damage secondary to shearing of the axons during the impact. Note that a fracture is not required to damage this tissue.

2) A secondary injury occurs when physiological free oxygen radicals form when the tissue is inflamed. Thus, damage is also incurred to the surrounding healthy tissue. This ultimately causes traumatic optic neuropathy, responsible for decreased vision and visual field defects.[12]

Visual Field Testing

The most common types of visual field defects secondary to traumatic optic neuropathy are altitudinal and arcuate, and they occur more commonly inferior centrally, paracentrally and cecocentrally.[12] Confrontation visual fields with simultaneous and single presentation are an appropriate screening tool, but may not pick up subtle defects. Visual field testing is necessary for anyone who has suffered trauma to the brain to rule out the common defects as well as others caused by damage along the visual pathway.

Visual examination should include a Humphrey visual field, which may be part of the second visit. Visual field testing in the TBI population is important to rule out defects but also to create a baseline for monitoring stability of the optic nerve pathway. Suchoff et al. reported in a retrospective study that 38.75% of the sample group of patients with TBI suffered a visual field defect. Of those who had visual field loss, the most frequent defect was a scattered pattern (58.06%) followed by homonymous hemianopia (22.58%).[13]

A SITA-standard 30-2 is the preferred quantitative test in these cases. If a patient is unable to maintain positioning for 10 minutes, a screening field such as a 76 point, 3 zone can be used. The screening examination looks for relative versus absolute defects, specifically quadrantanopias or hemianopias. For patients who are unable to maintain fixation, an Octopus visual field can be used for testing as this type of visual field tester can automatically adjust for fixation loss.

Ocular Motilities

Assessment of basic motilities including fixation, pursuits, and saccades is an integral part of each examination. Fixation should be evaluated for one minute in order to determine sustainability. The Northeastern State University College of Optometry (NSUCO)[14] procedures can be followed for the remaining pursuits and saccades portion of the evaluation. Ocular motor testing can exacerbate symptoms of dizziness, nausea, and headaches so caution should be taken in order to obtain as much information as possible without having to stop the exam. Monocular testing at a slow pace can be effective in reducing symptoms and allow testing to continue in an efficient manner.

Accommodation

Loss of accommodative function commonly occurs among patients with TBI of all ages, especially if the patient is approaching the age of presbyopia. Ciuffreda et al. recently reported accommodative dysfunction as the most common visual disability in the TBI population.[15] When testing accommodation, it is important to test amplitudes as well as the facility or flexibility of the focusing system.

Accommodative amplitudes are best documented with the minus lens to blur test because it avoids overestimation of amplitude due to relative magnification that is characteristic of the push-up method. Minification is a concern with minus lenses so 13 inches is used as a testing distance with a working distance adjustment of 2.50 diopters to compensate for underestimation of amplitude.[16]

Monocular and binocular accommodative facility testing for adults should be done using a testing distance 45% of the age related amplitude and lens powers of 30% of the amplitude, timed for 1 minute.[16] For the binocular accommodative facility testing, a suppression control, such as red/green glasses with red/green acetate, should be used over single letter targets. Accommodative convergence flexibility should be tested by performing a near point of convergence, noting break and recovery. Testing should include distraction such as talking to the patient to determine whether their system sustains without concentration. Patients should be instructed to follow the accommodative target until they see two, recover back to one, look at a distant target, and then recover bifixation back to the accommodative target. Some patients may not have this degree of flexibility in their accommodative convergence system and may therefore benefit from vision therapy.

Binocularity and Stereopsis

Binocularity assessment should include a cover test, phorias, and vergences at distance and near. Phorias and vergences are best done in free space with prism bars and moderately large simple targets (i.e. "T" or "E"). Limited ranges are often contributory to the patient's symptoms and should not be ignored.

Acquired diplopia is common following a TBI. It may result from a cranial nerve palsy, orbital fracture, or inflammation from the injury. It is critical to rule out pathology in the differential diagnosis process before assuming the diplopia is the result of a decompensated strabismus or binocular deficit. The most common cause of diplopia among patients with TBI is a superior oblique palsy (cranial nerve IV), as it is the thinnest and longest neural connection from the brain stem to the eye. The cover test in nine cardinal gazes and/or red lens test are used to evaluate comitancy of a deviation. Similarly, the Park's Three Step is used to isolate the limited muscle when a hypertropia is present. It is important to remember that some noncomitant deviations can become comitant over time. Frequent assessments will help determine if the deviation is improving or changing.

Stereopsis with a Random Dot Stereogram determines if the patient is bifoveal. The "R + L" can be used as a suppression check to assess whether the angle of deviation is longstanding or of recent onset. Suppression is often found among younger patients but rarely in older patients, unless a preexisting binocular anomaly was present. Stereopsis testing can also help in the decision as to whether compensatory lenses or prisms can be prescribed for fusion.

Visual Integration

Basic visual skills are the building blocks to achieving integrative motor tasks, such as navigation and ambulation, also known as orientation and mobility. If sensory input (visual acuity, visual field and ocular health integrity) or motor output (versions, saccades and vergences) are diminished, it may be difficult for the patient to adapt within a busy environment.[14] For example, if a patient is unable to judge the distance and speed of a car coming towards him/her it is difficult to cross a street. These patients may also complain of losing balance and bumping into things. Angels in the Snow, and chalkboard circles are two examples of two integrative visual sensory gross motor visual processing tests. The Romberg test can also be used to evaluate gait and balance. Visual Motor Integration, Test of Visual Perceptual Skills, Piaget Left/Right Awareness, and the Auditory Visual Integration Test are just some the visual perceptual tests that allow clinicians to see how patients function during integrative visual sensory fine motor tasks.

Management

After basic visual skills are evaluated and assessed, a treatment plan should be developed based on the diagnoses and the individual needs of the patient. Research has shown vision rehabilitation, including oculomotor therapy, can improve the recovery time of patients receiving active therapy. In one study, the mean recovery time was reduced by 2 months in patients receiving oculomotor training.[17] A vision rehabilitation program that is 3 to 10 weeks in length has shown significant improvement in recovery of smooth pursuit movements after TBI.[18] One must consider that oculomotor function is not only affected by deficiencies of saccades and pursuits. Accommodative function and binocularity serve to stabilize fixation.

Progression through rehabilitation is usually at a slower rate in comparison to a typical vision therapy patient. For example, patients with TBI initially need individual training sessions in a quiet non-distracting environment. Eventually moving to a distracting environment after improvement of symptoms to build endurance is a crucial step. Early in rehabilitation, targets should be large and simple in design. The homework must be relatively easy and adaptable to a patient's schedule. In the beginning, exercises should be done at the end of the day to increase visual stamina and reduce visual fatigue. Shorter treatment time periods throughout the day may be considered for someone who cannot endure a long period of therapy.

After visual, sensory and motor difficulties are addressed, visual perception can be incorporated into therapy. Visual perception is the highest level of visual skill integration within the central nervous system.[7] Depth perception, visual closure, spatial relationships and figure ground discrimination are just a few advanced skills needed to construct and navigate within the environment around us as well as perform fine motor tasks. Together, all of these visual skills will create a strong foundation for other physical rehabilitations.

CONCLUSION

This article is an overview of some of the modified procedures that should be implemented for the examination and management of visually symptomatic TBI patients. The examination, diagnosis and treatment plan should be specific to the individual's visual needs. Therapy must be individually constructed based on diagnoses made through these examination modifications. Optometric services are a crucial part of the integrative care given to these patients as vision rehabilitation is the foundation for other occupational or physical therapies. It can make the difference between progressing well through rehabilitation or remaining symptomatic. The interdisciplinary rehabilitative team's ultimate goal is to return the patient to a healthy, productive, and independent daily life. Optometry must be part of that team.

Appendix 1 : Head Trauma Vision Rehabilitation Unit Patient Survey (Head Trauma Visual Rehabilitation Unit at the State University of New York, State College of Optometry)

Patient Name: ____________________ MR# ____________ DOB: ____________

Staff Doctor ____________ Date Survey Completed: __________ Dx: ____________

Pre-/Mid-/ Post-Tx: ____________________ Type of Tx: ________________________

PLEASE RATE YOUR ABILITIES IN DOING THE FOLLOWING TASKS
(0=Poor, 1=Fair, 2=Average, 3=Good, 4=Excellent):

1. Writing _____
2. Daily Reading _____
3. School/work reading _____
4. Daily Math _____
5. School/ work math _____
6. Sustaining visual attention (20 min) _____
7. Sustaining visual attention (40 min) _____
8. Sustaining visual attention (>60min) _____
9. Walking around _____
10. Doing your job _____
11. Doing your hobbies _____
12. Doing sports _____
13. Overall functioning as of today _____

PLEASE RATE HOW OFTEN YOU EXPERIENCE EACH OF THE FOLLOWING SYMPTOMS
(0=Always, 1=Often, 2=Occasionally, 3=Rarely, 4=Never):

1. Blurred vision at distance _____
2. Blurred vision at near _____
3. Double vision at distance _____
4. Double vision at near _____
5. Headaches associated with near work _____
6. Asthenopia (eyes hurt when reading) _____
7. Lose place when reading/ re-read sentences _____
8. Become sleepy/ disinterested when reading _____
9. Avoid near vision tasks _____
10. Short attention span for near vision tasks _____
11. Become car sick/experience motion sickness _____
12. Inaccurate with judging distances _____
13. Misplace or lose papers/objects _____
14. Have trouble with scissors/ small tools _____
15. Tendency to walk/ bump into things on one side _____
16. Tendency to forget to dress one side of the body _____
17. Forget to shave/ put cosmetics on one side of face _____
18. Tendency to forget food on one side of plate _____
19. Aware that part of vision is missing _____
20. Unaware of cars/ pedestrians in traffic _____

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