Optometric Co-Management of a Traumatic Brain Injury Patient

Ingryd J. Lorenzana, OD, FAAO
Kelly A. Frantz, OD, FAAO

Each year more than 80,000 U.S. citizens survive traumatic brain injury (TBI) but are discharged from the hospital with TBI-related disabilities. According to the Centers for Disease Control and Prevention (CDC, 2000), an estimated 5.3 million Americans are living today with TBI-related disabilities. TBI truly is an enormous public health problem. The Centers for Disease Control and Prevention (2000) estimated the total lifetime cost of care for those suffering TBI in 1985 to be $37.8 billion. As a result, the CDC has committed to helping finance TBI prevention programs and more effective treatment strategies (Centers for Disease Control and Prevention, 2000).

The disabilities caused by TBI may affect a single function or a combination of functions. One area frequently impaired is cognition, which encompasses concentration, memory, judgment, and mood. Another area often affected is motor ability, which includes strength, coordination, and balance. Also, impairment can occur in the special senses, such as tactile and vision (Centers for Disease Control and Prevention, 2000). An important consideration in the rehabilitation of individuals suffering TBI-related disabilities is the impact of undiagnosed vision problems.

A poorly functioning visual system can have a negative impact on the patient's cognitive and motor functioning. Because the visual system plays such an important role in cognitive and motor processes, it is, therefore, imperative to evaluate the visual system thoroughly after TBI to determine whether additional intervention is indicated.[1]

A comprehensive functional visual evaluation encompasses three aspects. First, a primary vision examination rules out reduced visual acuity, need for lens prescription, and ocular disease conditions. Next, a visual efficiency assessment evaluates monocular (one eyed) visual skills, binocular skills (eye teaming), and the interrelationship of the two. Monocular skills include accommodation (focusing) and oculomotor skills (eye movement control). Accurate focusing allows clear vision when looking at objects at various distances. Eye movement skills allow efficient shifting of gaze (for example, tracking across a printed page). The binocularity evaluation is broken down into two components, motor and sensory. The motor component is further subdivided into ocular alignment and the ability to work toward alignment (by converging or diverging) when a muscle imbalance is present. The sensory component pertains to whether the eyes are registering information to the brain as a team or individually, even though the eyes may be aligned.

The final component of a comprehensive visual evaluation is analysis of visual perception. Visual perception allows problem solving through cognitive processing of visual input and information from other senses.[2] Examples of visual perceptual skills include visual form constancy (the ability to consistently identify forms despite changes in size or orientation),

Correspondence regarding this article should be directed to Ingryd J. Lorenzana, OD, FAAO or Kelly A. Frantz, OD, FAAO, Illinois College of Optometry, Illinois Eye Institute, 3241 S. Michigan Avenue, Chicago, IL 60616.

THIS ARTICLE HAS BEEN REPRINTED WITH PERMISSION FROM THE FALL 2001 ISSUE OF THE JOURNAL OF COGNITIVE REHABILITATION.

visual figure-ground (the ability to differentiate an object from its background), and visual closure (the ability to appreciate a form despite lack of certain details). Visual skills, such as acuity and eye movement control, are the basis for higher-level processes, such as visual perception. Disruption to the basic skills can lead to disruption of more complex skills.[2]

The following case illustrates application of the functional optometric evaluation for a patient who was suffering from visual disabilities as a result of TBI. It also demonstrates how optometric management of basic vision problems can have a positive impact on the rehabilitative process.

CASE REPORT

A 24-year-old man undergoing occupational and physical therapy was seen in the Binocular Vision Service of the Illinois Eye Institute. Medical history revealed a traumatic brain injury secondary to a motorcycle accident in which he was not wearing a helmet. In the accident, the patient was thrown 75–100 feet; he fractured his left mandible and was in a coma for 5 weeks. Before the accident, the patient reported having had an unremarkable medical/ocular history and had never worn glasses. He had been a certified automotive mechanic, employed full-time.

The patient's occupational therapist was concerned that occupational therapy was not progressing. She wanted a visual functioning exam to rule out visual components hindering therapy progress. Her goal for the patient was to develop the capability for such basic self-maintenance skills as finding his way home, writing checks, or shopping for groceries. The patient complained that he was not able to write checks because his vision was blurry and double when reading or writing. He purposely avoided reading and other close work. His goal was to regain independence and return to being a full-time auto mechanic. Before the accident, he had been able to drive himself wherever he chose; now he had to rely on other people to drive him, or he would get lost.

At initial evaluation, examination of the external eye structures and a dilated internal exam revealed no abnormalities in either eye. Media were clear, the retinas were intact, and there was a normal cup to disc ratio of 0.25 in each eye. The pupils were equally round, reactive to light/accommodation, and there were no color vision anomalies detected in either eye. Goldmann intraocular pressures were 15 mmHg in each eye (normal). A Goldmann perimeter detected no visual field defects in either eye. The refraction revealed mild astigmatism, requiring a prescription of right eye: plano −0.75 × 180 (20/20) and left eye: plano −0.75 × 180 (20/20) at distance and near. However, with this prescription, the patient expressed that his vision was still intermittently double at distance and near, and intermittently blurry. Overall, the ocular health was unremarkable, and the refractive correction was minimal.

In contrast, the visual efficiency evaluation showed decreased monocular skills. Fo cusing ability measured 6–8 diopters in each eye with constant fluctuation and poor control of focusing flexibility. This level of focusing is below normal for a patient his age. Eye movement skills were inaccurate, as shown by the Developmental Eye Movement test (DEM).[3] The patient showed reduced ability to process the numbers on the test automatically, as well as a high number of omission and transposition errors.

Furthermore, during assessment of binocularity, eye alignment testing showed an eye muscle imbalance that occurred intermittently and alternated between eyes. When present, it fluctuated in size from 5–12 prism diopters of exotropia (a relatively small magnitude of outward eye deviation) at distance and near. Convergence and divergence testing [base-in: ×/6/2 (distance), ×/12/6 (near) and base-out: 10/16/0 (distance), 6/16/0 (near)] showed that the patient did not have the ability to keep the eyes working together to compensate for the eye muscle imbalance.

Sensory testing included evaluation of depth perception. The Randot stereopsis test showed that at times the patient appreciated depth perception and at other times he did not. The Worth 4-dot found intermittent, alternating suppression (sometimes the patient ignored visual input from one eye). This result correlated with the finding that the patient appreciated depth perception only intermittently. To appreciate fine depth perception, both eyes have to work simultaneously so that dual visual images are registered to the brain.

The sensory findings also were consistent with the results of eye alignment testing.

When the patient's eyes were aligned, he registered information from both eyes to the brain and appreciated depth perception. When the patient's eyes were misaligned, he would attempt to compensate by one of two possible scenarios. In one case, he ignored input from one eye (as seen on Worth 4-Dot) and did not transmit information to the brain from both eyes. In the other case, he received input from both misaligned eyes and experienced double vision. These alternating visual situations cause visual confusion, which leads to visual stress, which in turn results in decreased speed of visual processing and potentially decreased reading comprehension. Ultimately, patients who experience such a stressful visual cycle end up frustrated and avoid near tasks completely, as in the case of our patient.

The visual perceptual evaluation included the Morrison Gardner Test of Visual–Perceptual Skills (nonmotor)—Revised,[4] which showed severe deficits in the areas of visual memory, visual form constancy, visual figure-ground, and visual closure. Visual–motor skills were tested using the Beery–Buktenica Developmental Test of Visual–Motor Integration.[5] The results showed a severe deficit in visual–motor integration. The patient was also screened for disorders of higher cortical functioning to rule out alexia, simultagnosia, visual neglect, and visual agnosia. This screening indicated that the patient was not experiencing any of those disorders.

DIAGNOSIS AND INTERPRETATION

Based on the case history and results of the comprehensive optometric visual evaluation, the patient was assessed with low myopic astigmatism in both eyes and Post-Trauma Vision Syndrome (PTVS). This syndrome is defined by the presence of eye movement, focusing, and eye teaming dysfunction secondary to head trauma.[1] The patient showed deficient monocular skills characterized by decreased focusing ability and inaccurate eye movements/fixations. The binocular dysfunction in this patient was characterized by an intermittent eye muscle imbalance, without the corresponding compensating ability. There also were visual information processing deficits in the areas of visual–motor integration, visual memory, visual form constancy, visual figure-ground, and visual closure. Warren[2] has described such visual perceptual deficits in patients following TBI.

The evaluation results provided insight into the cause of the patient's complaints and the occupational therapist's concerns. The patient was demonstrating many of the classic signs reported in the literature for a patient with PTVS.[1] The double vision was attributed to the intermittent exotropia. The size of the angle of deviation was considered to be a normal amount, for which most people are able to compensate. However, because of the trauma incurred by the visual system, the patient was not able to compensate for such a small angle.

The patient's complaints of blur and eyestrain at nearpoint were caused by the focusing and eye movement dysfunctions. The therapist's concerns regarding the patient's difficulty with check writing and grocery shopping skills could be attributed to the deficient monocular skills, binocular skills, eye–hand coordination, and visual perceptual deficiencies.

Patients suffering from PTVS benefit from a vision therapy program targeted to enhance all of their visual deficiencies. Such a program is most successful when the optometrist is part of the rehabilitative management team and therapy is integrated into the patient's overall plan along with the physical and occupational therapies. However, this patient al ready was undergoing physical and occupational therapy in a rehabilitation center and adding another site for him to visit during his already heavy weekly schedule was overwhelming. An alternative plan was put in place.

TREATMENT PLAN

The treatment plan consisted of several steps. First, the patient was prescribed glasses with prism to relieve the double vision. Also, an attempt was made to prescribe bifocals to help with the focusing insufficiency. However, when educating the patient on the benefits of bifocals, he did not like the idea of wearing them. It was decided not to prescribe bifocals to improve the likelihood that the patient would wear his glasses. The patient's glasses included a small prescription to correct the astigmatism (which improved visual acuity) and 2 prism diopters (p.d.) of base-in prism in the left eye to alleviate the eye muscle imbalance. The amount of the prism was determined by measuring the smallest amount of prism that provided single comfortable vision for far and near viewing.[8]

Second, the occupational therapist was informed about the deficient visual skills and given compensatory suggestions to achieve greater success in occupational therapy. The compensatory techniques were geared toward the therapist's goals of enabling the patient to write checks and to go grocery shopping. For example, in regard to check writing, we recommended using large size checks for less focusing demand, a large size pen to decrease the eye–hand coordination demand, and isolating written words with a typoscope (which isolated one portion of the check at a time) to decrease the figure–ground component as well as the demand for accurate eye-aiming skills.

Finally, with optometric guidance, the therapist was able to incorporate some vision therapy for eye movement and eye–hand coordination skills into the patient's therapy regimen. Some of the eye movement techniques used by the occupational therapist included Hart Chart (letters arranged in rows and columns) and prism saccades, Perceptual-Motor Pen, and tachistoscope. These techniques emphasize practicing rapid and accurate eye movements, accurate eye–hand coordination, and precise aiming of the eyes at a particular group of letters, which appear only briefly and must be viewed quickly and then recalled using short-term memory.

FOLLOW-UP AND CONTINUING PLAN

The patient failed to return for a 3-month follow-up visit. However, follow-up consultation with the occupational therapist revealed progress with occupational therapy after implementation of the compensatory recommendations.

The patient returned to the eye clinic 1 year later. At this visit, he reported wearing the previously prescribed glasses full time and admitted having returned because the double vision had reappeared, and the glasses no longer relieved it. Pertinent findings at this visit were an intermittent, alternating exotropia (outward deviation) at distance of 2–4 p.d. and a constant alternating exotropia at near of 10–12 p.d. There also was a vertical deviation of 3 p.d. left hyper. By means of the Maddox rod technique[9] the axis for oblique prism was determined, and the smallest power that provided subjectively single, comfortable vision was prescribed at that axis. After trying on the oblique prism on two separate visits to check reliability, the patient was prescribed 1.5 p.d. base-in and down at 1940 left eye for full-time wear and was to return in 3 months for follow-up.

At his most recent visit, the patient demonstrated increased self-confidence and less frustration with himself. He had been able to resume driving and had returned to school to study auto mechanics while maintaining a part-time position in the field. He had completed his occupational therapy; activities of daily living were much easier for him now. His vision was clear at all distances. He did, however, report double vision again, but it was at nearpoint only, occurred approximately 5% of the time, and his prism glasses did not relieve the double vision as before. Pertinent findings at this visit included orthophoria (no deviation) at distance, and 6 p.d. intermittent, alternating exotropia with 2 p.d. left hypertropia at near (slight outward and upward deviation). The patient had no depth perception without prism but appreciated depth with 2 p.d. base-down prism before the left eye. Ability to turn the eyes inward was still reduced, but it improved when tested with this prism power. Subjectively, the patient did not prefer any horizontal prism, but noticed improved comfort for near work with 2 p.d. base-down left eye. Thus, this prism power was prescribed in glasses to be used for near tasks only.

DISCUSSION

This patient demonstrated classic PTVS, as seen in many survivors of traumatic brain injury.[1] These patients commonly experience inaccurate eye movement and focusing control, strabismus, poor motor fusion, reduced depth perception,[1] and visual information processing dysfunction.[2,10] Also common are visual field defects,[11,12] dry eyes secondary to incomplete eyelid closure[13] and decreased blinking rate,[1,14] cranial nerve involvement,[13] refractive error changes,[14] and decreased contrast sensitivity.[2] Common ocular symptoms noted by patients with traumatic brain injuries include: blurred and/or double vision, eyestrain, problems with focusing, spatial orientation, balance, posture, and visual memory.[1]

These patients also frequently report problems with daily activities such as reading.[15] A thorough optometric evaluation for these patients is essential to rule out the possibility of multiple visual functioning deficits. Our work-up was similar to those recommended in the optometric literature.[16,17]

This case demonstrates that there are more critical aspects to visual functioning than 20/20 vision. These include accurate and efficient eye movement, focusing, binocular coordination, and visual perception. Vision therapy has been shown to improve these skills in many patients.[7,18–20] In this particular case, due to geographical issues, the patient was unable to participate in a vision therapy program. Ideally, he would have received vision therapy in an optometric office setting for a minimum of three–five times a week for at least 12–18 weeks. The use of various prism prescriptions during our patient's rehabilitation was important in improving teaming of the two eyes and overall functioning. The changes in angle of eye deviation and compensating ability shown by this patient over the course of his rehabilitation are commonly found with patients who have had similar injuries. These changes in visual functioning illustrate the importance of close monitoring by the optometrist, to alter the treatment plan as the patient progresses.

CONCLUSION

The optometrist can provide valuable information regarding a patient's visual functioning, which can aid the rehabilitation process if it is addressed appropriately. If these visual problems are not addressed, patients may not reach their full rehabilitative potential. Thus, we recommend that TBI patients undergo a thorough functional optometric evaluation as early in their rehabilitation program as possible.

ACKNOWLEDGMENTS

A portion of this paper was presented as a poster at the Annual Meeting of the American Academy of Optometry, San Antonio, December 1997, and at the 22nd Annual Williamsburg Conference on Cognitive, Neuromedical and Behavioral Aspects of Brain Injury, June 1998. We wish to thank Dr. Janis Moore for her participation in the management of this patient, and Mr. Gerald Dujsik and Drs. Neil Hodur and Michael Volin for their helpful comments on the manuscript.

REFERENCES

1. Padula WV, Shapiro JB, Jasin P. Head injury causing post trauma vision syndrome. *N Engl J Optomet.* 1988;Dec/Winter:16–21.
2. Warren M. A hierarchical model for evaluation and treatment of visual perceptual dysfunction in adult acquired brain injury, part 1. *Am J Occupat Therapy.* 1993;47:42–52.
3. Richman JE, Garzia RP. *Developmental Eye Movement Test, Version 1, Examiner's Booklet.* Mishawaka, IN: Bernell Corp; 1987.
4. Gardner MF. *Test of Visual–Perceptual Skills (nonmotor)—Revised, Manual.* Psychological and Educational Publications, Inc.; 1996.
5. Beery KE. *The Beery–Buktenica Developmental Test of Visual-Motor Integration Administration Scoring and Teaching Manual.* 4th ed. Parsippany, NJ: Modem Curriculum Press; 1997.
6. Berne SA. Visual therapy for the traumatic brain-injured. *J Optomet Vision Develop* 21:13–16.
7. Ciuffreda KJ, Suchoff IB, Marrone MA, Ahmann E. Oculomotor rehabilitation in traumatic brain-injured patients. *J Behav Optometry* 1996;7:31–38.
8. Caloroso EE, Rouse MW. *Clinical Management of Strabismus.* Boston: Butterworth-Heinemann. 1993;94–112.
9. Moradiellos DP, Parrish DE. A clinical technique for correcting diplopia with prism. *J Am Optomet Assoc.* 1986;57:740–743.
11. Tierney DW. Visual dysfunction in closed head injury. *J Am Optomet Assoc.* 1988;59(8):614–622.
12. Warren M. A hierarchical model for evaluation and treatment of visual perceptual dysfunction in adult acquired brain injury, part 2. *Am J Occupat Therapy.* 1993;47:55–66.
13. Vogel MS. An overview of head trauma for the primary care practitioner, Part I—Etiology, diagnosis, and consequences of head trauma. *J Am Optomet Assoc.* 1992;63:537–541.
14. Kadet TS. Visual dysfunctions in traumatic brain injury (TBI). *Washington Optom Today.* 1992;14(3):12.
15. Hellerstein LF, Freed S. Rehabilitative optometric management of a traumatic brain injury patient. *J Behav Optomet.* 1994;5:143–148.
16. Cohen AH. Optometric management of binocular dysfunctions secondary to head trauma: Case reports. *J Am Optomet Assoc.* 1992;63:569–575.
17. Falk NS, Aksionoff EB. The primary care optometric evaluation of the traumatic brain injury patient. *Am Optomet Assoc* 1992;63:547–553.
18. Birnbaum MH, Soden R, Cohen AH. Efficacy of vision therapy for convergence insufficiency in an adult male population. *J Am Optomet Assoc.* 1996;70:225–232.
19. Rouse MW, Borsting E. Management of Visual Information Processing Problems. In: Scheiman MM, Rouse MW, eds. *Optometric Management of Learning Related Vision Problems.* St. Louis: Mosby-Year Book; 1994, 432–433.
20. Suchoff IB, Petito TG. Efficacy of visual therapy: Accommodative disorders and non-strabismic anomalies of binocular vision. *J Am Optomet Assoc* 1986;57:119–125.

Aksionoff EB, Falk NS. The differential diagnosis of perceptual deficits in traumatic brain injury patients. *J Am Optomet Assoc.* 1992;63:554–558.

Traumatic Brain Injury Page. Centers for Disease Control and Prevention. January 30, 2001 http://www.cdc.gov/ncipc/dacrrdp/tbi.htm.