Optometric management of binocular dysfunctions secondary to head trauma: case reports

ALLEN H. COHEN, O.D.

ABSTRACT: Extropia, esotropia, hyper elements, visual sequencing problems, accommodative dysfunctions and inefficient Motor Planning are common consequences of head trauma. Optometric visual therapy is an effective treatment modality for these dysfunctions. Two case reports are presented in order to illustrate optometric management of patients exhibiting these problems secondary to head trauma.

KEY WORDS: head trauma, strabismus, esotropia, exotropia, convergence insufficiency, visual therapy, visual training

Cohen AH. Optometric management of binocular dysfunctions secondary to head trauma: case reports. J Am Optom Assoc 1992; 63:569–75.

Accidents resulting in closed head trauma commonly affect the cranial nerves and can cause visual field defects. Cranial Nerves III, IV and VI are most commonly involved, causing esotropia and exotropia and vertical deviations.[1,2,3] The patient usually experiences symptoms of diplopia and confusion secondary to the binocular breakdown.

As a member of the rehabilitation team, one role of the doctor of optometry is to advise other professionals about the patient's visual deficits and the impact of the visual loss on the patient's total rehabilitative process. The optometrists also will provide treatment to eliminate any visual dysfunction resulting from the trauma, or enhance the visual skills, as well as the detection and management of ocular disease when appropriate.

Optometric treatment incorporates the management of ocular disease either directly or by co-managing these with other health care professionals, as well as the prescribing of therapeutic lens systems, therapeutic prisms, treatment prisms (yoked prisms), selective occlusion, low vision treatment modalities when appropriate, optometric visual therapy and the integration of optometric visual therapy with physical therapy, occupational therapy and cognitive therapy.

The following case reports illustrate two examples of optometric management of head trauma patients:

Case I

Primary care evaluation

Case history

A 25-year-old male patient sustained injury to his head while riding his bicycle. He was struck by a truck and was projected forward, hitting his head. Since he was not wearing a protective helmet, he sustained a frontal, closed head trauma of the accelerative/decelerative type. This type of trauma is a common occurrence from a car accident and causes injury to brain tissue from impact caused by a moving object on a stationary or slower moving object (accelerated), and/or diffuse injury to brain tissue secondary to its movement within the skull (decelerative). He was in a coma for 3 weeks, and when he emerged from the coma, he manifested hemi-paresis motor deficits on his right side, diplopia and significant language deficits. He had 2-1/2 years of physical, occupational and cognitive therapy at a rehabilitation center.

Prior to the accident, he was studying accounting and was an avid reader. There was no prior history of an eye turn or double vision, although he did wear glasses for the correction of myopia.

The neuropsychologist at the rehabilitation center did not think that there were any significant problems; therefore, he began extensive therapy using computers. He did not respond well to this therapy, becoming easily frustrated because he experienced visual confusion such as reversals, misalignment of columns of numbers, sequencing difficulties and diplopia, as well as headaches. He avoided reading and other close work.

Ocular health

External examination of the eyes and adnexa revealed no abnormalities. A dilated examination, utilizing direct and indirect ophthalmoscopy and a Volk +90 lens, revealed clear media, an intact retina with normal eye grounds and a normal optic nerve head with a C/D ratio of .3 in each eye. The pupils were equal and round and reacted normally to light and accommodation. Computerized visual field evaluation was within normal limits, IOP with Goldmann tonometry was 16mm. in each eye.

Sensorimotor evaluation

Motor alignment: At distance, the cover test revealed a 10^ exophoria with a slow motor recovery. Red lens testing elicited crossed diplopia, with a slow recovery characterized by difficulty sustaining fusion.

At near, the cover test revealed a constant, alternating exotropia of 18^. The red lens at 16″ elicited crossed diplopia. However, this same test revealed sensory binocular fusion from 14 feet to infinity.

Ocular motility: Voluntary pursuits and rotations were concomitant with full excursions in all fields; however, the quality of the movement was characterized by mild oscillating nystagmoid movements accompanied by significant tearing.

Refractive analysis

The manifest refraction yielded the following prescription: OD−5.00−0.75×15 VA20/20 and OS−3.25−1.25×180 VA20/20. Visual acuity at near with this prescription was 20/20 in each eye. However, the patient expressed difficulty maintaining clear focus with this correction, which was accompanied by tearing and other signs of visual stress.

Fusional vergence ranges were not measured because of diplopia response secondary to the exotropia. Further in-depth fusional testing was performed during the expanded sensory motor examination.

Dynamic nearpoint retinoscopy utilizing MEM targets revealed a lag of accommodation of +1.75 OU. With this add, the patient stated that he could see the print clearly, and maintain clarity in a comfortable manner.

Sensorimotor evaluation (expanded)

The visual therapy/orthoptic workup revealed the following:

Motor alignment: At distance an intermittent exotropia with a slow recovery was measured. However, when wearing red/green glasses and looking at an illuminated source covered by a red sheet of plastic with a central cut out target of green plastic (Cohen Test)[1] (Fig. 1), the patient manifested constant crossed diplopia. He required 2^ BI combined with 2^ BD OS in order to fuse and sustain alignment.

At near, an alternating constant exotropia of 15^ BI was measured. With this prism correction in place, and having him place a pointer in a straw, an ocular alignment response was elicited at 14″-10″.

Accommodative status: Using a ±2.00 flipper monocularly, at near, he was unable to clear minus lenses with either eye within 10 seconds. However, he cleared the plus lenses in either eye in 2–4 seconds. The Binocular Flipper test was not performed because of the diplopia.

Evaluation of fusion potential: Fusion ability at near aided by stereo clues was evaluated utilizing the Clown Vectogram.[a] He experienced "silo" awareness, localization and stereo float. Divergence ranges were adequate measuring x/p/m; however, the convergence ranges were restricted measuring X/8/3. He achieved a stereo response with the Stereo Fly Test[a] corresponding to 60 secs. of arc with Wirt circles. Flat fusion was evaluated with the AN#1 card in a stereoscope as well as with the Keystone Visual Skills Series. He could not fuse the AN#1 card, and Keystone Visual Skills testing demonstrated high underconvergence at distance and near; however, on the stereo subtest of the Keystone visual skills, he appreciated all targets correctly. The fact that the stereo demand helped him fuse indicated a better prognosis.

Assessment of higher cerebral function

Morrison Gardner test of visual perception (non-motor)[4] - he achieved scores within the 98th percentile for the visual spatial relations subtest, 99.6th percentile for the visual figure-ground subtest and the 75th percentile for the visual sequential memory subtest.

Visual memory - Short term visual memory was evaluated with the Monroe III test and Tachistoscope Speed and Span of Perception.[5] He scored 12.5 on the Monroe III test, which is below what is expected for a child 13 years old and therefore below what would be expected for him. He was able to achieve four numbers at 1/1000 on the tach speed and span of perception tests. This is a good response for this testing probe.[5]

Assessment of visuo-motor skills - These skills were evaluated using the Beery Developmental Test of Visual Motor Integration, NYSOA K/D test and the Wold

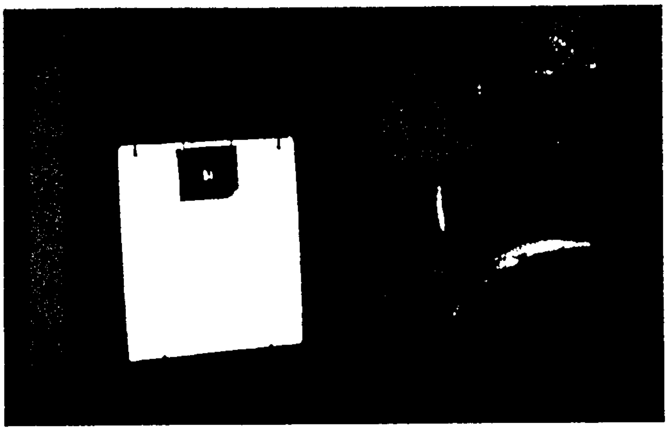

Figure 1: Cohen Test

Digit/Symbol Copy Test.[b] These tests, as well as other tests that assess visuo-motor and oculo-motor development are generally only standardized to adolescent age levels.[6] Therefore, when evaluating a patient with head trauma, two criteria are used; is the quality of the performance and the patient's response at age level or at the highest standardized level if the patient is above that age. Since documentation and interpretation of the patient's response to the testing probes is based on subjective criteria, the clinical experience of the practitioner is important. For example, on the Beery VMI Test, pencil grip, grapho-motor control and form reproduction are all assessed. The patient's results were above the maximum standardized norms on all tests and his performance was appropriate.

Diagnosis and recommendations

As a result of the diagnostic testing and case history questions, the following diagnoses were reached:

1. Binocular dysfunction characterized by a poorly compensated exophoria at distance, and a constant alternating exotropia with a left hyper component at near.
2. Visual sequencing deficits as demonstrated by the following: a) patient's responses of difficulty expressing his thoughts verbally b) His inability to develop a sequential theme in his written work as well as a score at only the 75th percentile on the visual sequencing subtest of the Morrison Gardner test of visual perception.

Optometric visual therapy was recommended. The goals were to eliminate the exotropia and to develop efficient visualization skills to be used as a base for further remediation by a speech and language professional.

Overview of therapy

Phase I

A common problem that head trauma elicits is an inability to initiate a coordinated motor response to sensory stimuli. This also holds true for ocular motor responses. An example of a treatment modality used to develop this skill employs prisms monocularly to cause a space shift of a stimulus. The patient responds to the displacement created by the prism with an ocular motor response. The accuracy of the response is reinforced and conditioned by various feedback mechanisms. The following description is an example of this technique. The patient had to track a moving object on a CRT screen while wearing monocular BO prism, and at the same time, had to match the direction of the movement by tracing it with a stylus on a quola pad (Fig. 2). It was stressed that he be aware of the proprioceptive feeling of his eyes adducting as well as the accuracy of the ocular motor responses. Clinically, we find that when dealing with head trauma patients with ocular motor and binocular dysfunctions, the development of this proprioceptive feedback and the ability to more effectively coordinate a sensory motor response helps in developing coordinated fusional vergence.

The next goal of optometric visual therapy was for him to enhance his near point of convergence and to develop adequate control of the exophoria at distance by developing adequate fusional vergences. Prisms and lenses were utilized in this treatment sequence in order to develop accommodative facility and convergence fusional ranges. Therapy procedures that required a response to a blur and/or diplopia generated by these lenses were selected in order to allow the patient to learn to converge or diverge his eyes while maintaining a clear image. Throughout the therapy, the patient was made aware of the proprioceptive feeling associated with the task demand.

Phase 2

The next phase of therapy was to develop convergence and divergence ranges utilizing vectographic techniques. The patient moved a pointer from outside of the horopter (locus of fusion) toward the point in space where the fused image is projected. The physiological diplopia response was used as a feedback to help develop sensory motor fusion and accurate spatial localization. An example is when he was made aware of the fact that the diplopic images of the pointer will converge as it approaches the point where the fused image is projected. As he was able to readjust his vergence system, the vergence demand was increased and the therapy cycle repeated until adequate fusional and accommodative convergence ability was developed.

Figure 2: Computer tracking

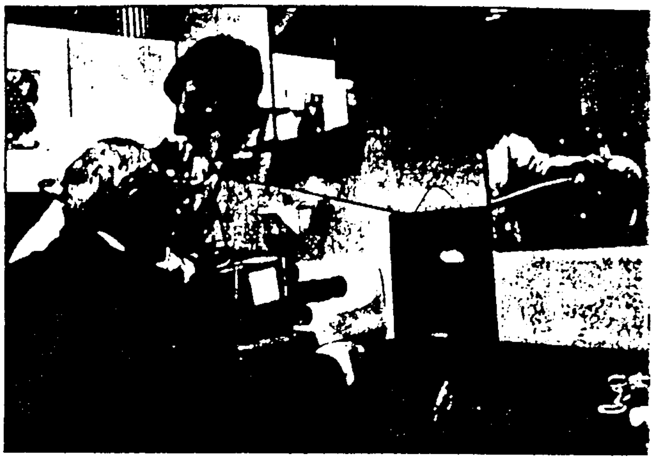

Figure 3: Prism reader

Phase 3

After adequate stereo fusional ranges were developed, therapy sequences were prescribed in order to develop the ability to make rapid divergence and convergence fusional changes in space, as this is important in real life situations. We utilized various "jump duction" techniques in space, again, underscoring proprioceptive feeling and physiological diplopia awareness. Finally, we introduced techniques to develop flat fusion ranges combined with accommodative controls. An example is the use of an instrument that has Risley prisms attached and a control for suppression (prism reader)(Fig. 3). The patient read sentences while varying changes in prism power was introduced. As he was able to fuse, the prism demand was increased until adequate flat fusion ranges were developed.

After 30 sessions of visual therapy, a reevaluation showed the following:

1. Distance phoria was 3^ of exophoria compensated by a convergence fusion range of x/12/6.
2. Near phoria was 12^ of exophoria with a compensating convergence fusion range of 24/26/14 and a divergence fusion range of 18/24/16.
3. Negative and positive relative ranges of accommodation measured +3.50 and −2.00 respectively. He reported that all of his symptoms were eliminated and that he was now able to read more accurately and comfortably but still had significant difficulty with sequencing and written expression. A program of therapy was prescribed geared to the development of both visualization skills and the processes for visual closure and visual sequencing. He was also referred to a teacher who specializes in language and communication disorders in order to remediate the deficit in these areas.

Case 2

Primary care examination

Case history

A 20-year-old male sustained a closed head injury in an automobile accident and was in a coma for 3 weeks. The neurological diagnosis indicated possible brain stem involvement. When he emerged from the coma, he experienced constant diplopia, poor vision (especially with his right eye), severe ocular pain in both eyes and the inability to produce tears. He also presented with significant motor deficits affecting the right side of his body.

He entered a rehabilitation program in an acute care rehabilitation center where he received physical therapy (PT) and ocular therapy (OT). He made significant improvement in his control and movement of the right side of his body, however, he still experienced ocular pain and constant diplopia associated with an esotropia. He was treated for the ocular pain by the staff physician who prescribed topical steroids.

Ocular health evaluation

External examination of the eye and adnexa revealed a partial paresis of the facial muscles of the right side combined with a right lid droop. There were numerous well-healed lacerations on his forehead. On tight lid closure, the palpebral fissure was 10mm, however, he had a good Bell's phenomenon. The left lid had normal closure.

Biomicroscopic examination was characterized by significant diffuse corneal staining with both fluorescein and rose bengal in both eyes. IOP measured with Goldmann tonometry was 16mm in each eye. Schirmer testing was 1mm in the right eye and 3mm in the left.

A dilated examination of the media, retina and posterior pole did not reveal pathology or abnormalities.

Sensorimotor evaluation

Motor alignment: The cover test at distance and near measured a constant, alternating esotropia of approximately 50^. With this prism and a red lens in place, he reported luster. This finding was interpreted as indicating fusion at the object angle of squint.

An assessment of ocular motor control was characterized by a non-comitancy associated with an inability to move either eye past midline on temporal gaze.

Refractive analysis

Unaided visual acuity was OD 20/50, OD 20/100 at distance. Nearpoint visual acuity was OD 20/40, OS 20/30 at 16".

The refraction was difficult to perform due to corneal edema and light sensitivity. Static retinoscopy findings at distance were OD +3.50 correcting the vision to 2/40; OS +2.00−1.50×90x correcting vision to 20/60. Keratometer readings were not valid due to irregular mires as a result of corneal distortion.

Diagnosis and recommendations

Diagnosis and recommendations were as follows:

1. Bilateral VIN palsy.
2. Right VIN palsy
3. Esotropia secondary to the VIN palsy
4. Severe dry eye syndrome secondary to VIN palsy

I recommended Lacrilube ointment at bedtime and discontinued the use of steroids. I also recommended the use of artificial tears during the day. A consultation with a corneal specialist was arranged in order to determine if more extensive medical management was indicated. The corneal specialist confirmed the diagnosis and performed a temporal tarsorrhaphy. He responded well to this treatment.

Since he was not able to start office therapy for 3 months, I prescribed basic monocular calisthenic exercises to be performed at home for 15 minutes a day, 4–5 days per week. The purpose of the home therapy was to attempt to relax any secondary contractures and muscle spasms that could be restricting his ability to move his eyes to maximum excursion. Muscle spasm and secondary contracture are common after head trauma and often can be reduced; this can reduce the angle of deviation. The basic goal of home therapy was to have the patient fixate a target with his eyes without moving his head or body. After fixating the target, he was asked to flash it with a flashlight. As previously discussed, the patient was encouraged to feel his eyes move, and also to accurately guide the flashlight to the target, in order to develop a more integrative visuomotor response. As he progressed, he performed therapy sequences while wearing monocular BI prism. This increased the magnitude of the required abduction movement. An example of this would be when he was asked to randomly fixate index cards with numbers written on them placed on a wall, while wearing monocular 15^ BI prism. He had to fixate the appropriate numbered card with his eyes without moving his head or body, and then accurately place the light of the flashlight directly on the number on the index card. A follow-up examination was recommended when he was ready to begin office therapy.

Follow-up evaluation

A follow-up examination was performed 3 months after home therapy. The following is a summary of the results:

The symptoms secondary to the corneal involvement were significantly reduced. The corneal surfaces were clear and healing well. Corneal reflections of the keratometer mires were of fairly good quality. Visual acuity measurements were OD 20/30; OS 20/25. The refractive findings were +1.25 in each eye.

There was significant improvement in range of movement of the eyes to temporal gaze; he was now able to move his right eye temporally 30 degrees and his left eye temporally 45 degrees. There was also a significant reduction in the objective angle of esotropia which now measured 40^ at distance and 28^ at near.

Extended sensorimotor evaluation (strabismic workup)

Motor alignment: At distance, a constant alternating esotropia was present. The objective angle of turn, measured with a cover test and prism, was 25^ at distance and near.

Ocular motor field of gaze: His field of gaze measured with an arc perimeter was restricted to 30 degrees when the right eye fixated temporally and 35 degrees when the left eye fixated temporally.[1]

Accommodative status: Utilizing a ±2.00 flipper monocularly at near, he needed 15 secs in order to clear the print with the minus lens with each eye. With the plus lens, he cleared the print immediately with each eye. He also noted that the plus lens made the print clearer.

Evaluation of fusion potential: The subjective angle measured 25^ BO utilizing the Cohen test as described earlier.[1] At near, with the 25^ correction, he demonstrated a centration range, and a luster response from

2–18″, however, he was able to achieve stereo awareness of the fly on the Stereo Fly Test but not on the Wirt circles. The objective angle measured in the synoptophore utilizing fusion targets was 24^ BO and 3^ BU OD. He was not able to maintain fusion over any significant range.

His fusional ranges were very limited even with the prism correction. He could not fuse the clown vectogram and could only fuse the large Quoit targets when a central fusional target was introduced.

Assessment of higher cerebral functioning

Morrison Gardner Test of visual perception (motor free):[4] The patient did well on all subtests scoring above the 95 percentile in each area.

Assessment of visuo-motor skills: Visuo-motor skills were assessed using the NYSOA K/D Test[a] and the Wold Digit Symbol Copy Test.[6] He performed at the highest standardized age level on each test, and his performance was accurate.

Diagnosis

As a result of this testing, a diagnosis of constant, alternating esotropia secondary to VIN involvement from head trauma was made.

Recommendations

Since a 25^ BO enabled him to fuse, I prescribed this Rx with the prism divided between the two eyes for constant wear and for all home therapy. I also prescribed a near Rx of +1.25 spheres, again incorporating the 25 BO prism. This Rx helped him fuse and focus print more easily. In-office optometric vision therapy was initiated in order to eliminate or reduce the need for prism correction by developing adequate compensating fusional ability. Another goal was to develop more efficient accommodative facility.

Summary of visual therapy

The patient attended in-office therapy for 50 sessions. This therapy was reinforced with a structured sequence of home therapy that was integrated into his total rehabilitation treatment. The following represents an overview of the therapy:

Phase I

The goal of the first phase was to reduce or eliminate any secondary contractures or spasms of the extraocular muscles in order to increase the field of fixation. For enhancement of abduction ability, I prescribed techniques that require monocular pursuits, rotations and saccadic fixations while he wore monocular BI prism. In order to reinforce the ocular motor response, I added feedback by utilizing tasks requiring proprioceptive responses. In order to improve ocular motor control, I placed a sponge on his head in order to maximize eye movement while limiting head movement. An example of this therapy sequence is to ask the patient to follow a moving target with his eyes while wearing monocular BI prism, and at the same time, maintain accuracy in keeping a light beam superimposed on a moving target.

Another goal of this phase of therapy was to attempt to normalize his accommodative facility. Standard techniques[7] were utilized. He was encouraged to feel the difference between the clearing plus and minus lenses in order to develop proprioceptive feedback.

Phase II

The goal of this phase of therapy was to increase fusional ranges and reduce the manifest esotropia and therefore the need for as much correcting prism. An optical centration point was created by prescribing the minimum prism needed to allow him to fuse. While wearing the prism correction, fusional ranges were developed by creating divergence and convergence demands in space using vectograms and mirrors, and reinforcing the motor movement with "mental effort" as feedback. An example is the expansion of his divergence fusional ability by asking him to imagine that he was watching an airplane take off on a runway and feel his eyes diverge. The vectogram targets were separated and he was encouraged to feel his eyes diverge using mental effort while attempting to fuse the targets. As his fusional ranges expanded, the correcting prism was reduced.

I also utilized jump duction fusional techniques to develop his ability to change levels of fusion and to recover fusion quickly.

Phase III

The goal of this phase was to develop fusion sustenance. At this point in therapy, he did not need any correcting prism. Flat fusion demands were presented using instrumentation such as stereoscopes, aperture rule and various techniques requiring chiastopic (convergence) and orthoptic (divergence) fusional responses.[7]

Final evaluation

The patient was dismissed from therapy after 50 visits. Visual acuity was 20/20 in each eye without correction. His field of gaze was full in almost all directions; only a slight limitation was evident when he looked up and to the right. Cover testing revealed a well controlled 5Δ-8Δ esophoria at distance and 8Δ-10Δ at near, with luster on the red lens test and excellent jump recovery.

Phorometric testing findings were:

Distance: BI X/9/6; BO X/30/24

Near: BI X/24/15; BO X/21/15

NRA=+3.25

PRA=−0.75

Stereo acuity was 40 SECS of arc with the Wirt Circles portion of the Stereo Fly Test.

He reported an absence of diplopia unless he looked to his extreme upper right field of gaze. He reported that he was playing tennis again, driving and planned to start school again. A final prescription of +1.50 spheres was prescribed for all near activities.

Discussion

The two cases presented represent typical head trauma patients who significantly benefited from optometric care. Case 1 illustrates typical deficits secondary to frontal lobe head trauma, i.e., exotropia with a hyper component, poor convergence and difficulty with Motor Planning. His language deficit was secondary to poor sequencing and an inability to plan his responses. The convergence insufficiency was influenced by his ability to "know how to Motor Plan" the convergence response.

Case 2 illustrates a patient with IIIN and VIN involvement who had significant functional and medical consequences. Optometric input had a significant impact on the patient's successful overall rehabilitation and his future goals. The fact that the rehabilitation team was not aware of the significant visual problems underscores the importance of optometric input into the total rehabilitation of head trauma patients.

There is a need for optometrists with special interests and training in rehabilitation to become members of the multidisciplinary team treating traumatic brain injured (TBI) TBI patients. ■

References

1. Cohen AH, Soden R. An optometric approach to the rehabilitation of the stroke patient. J Am Optom Assoc 1981; 52(9):795-800.
2. Fraco RF, Fells P. Ocular motility problems following road traffic accidents. Br Orthopt J 1989; 46(40):40-8.
3. Padula WV, Shapiro JB, Jasin P. Head injury causing post trauma vision syndrome. N Engl J Optom 1988; Dec/Winter:16-22.
4. Gardner MF. Test of visual perceptual skills (non-motor). Seattle: Special Child Publications, 1982.
5. Solan HA, Mozlin R, Rumpf DA. Selected perceptual norms and their relationship to reading in kindergarten and the primary grades. J Am Optom Assoc 1985; 56(6):461-2.
6. Aksionoff EB, Falk NS. The differential diagnosis of perceptual deficits in traumatic brain injury patients. J Am Optom Assoc 1992; 63:554-8.
7. Griffin JR. Binocular anomalies: procedures for vision therapy. Chicago: Professional Press.

Footnote

a. Bernell Corporation, 750 Lincolnway East, South Bend, IN 46618.
b. Another article in this issue (when Journal issue is finalized I will be able to complete this footnote).

Submitted 12/90 ; accepted 4/92

Optometry Service (123)
Northport VA Medical Center
Northport, NY 11768

SUNY State College of Optometry
100 East 24th Street
New York, NY 10010