Article

Vision Dysfunctions Secondary to a Motor Vehicle Accident: A Case Report

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ABSTRACT

Background: Traumatic brain injury (TBI) is a common consequence of motor vehicle accidents. One in every five cases of TBI has a motor vehicle involved in its etiology. Patients with TBI have been found to have a high prevalence of vision symptoms and dysfunctions. This case report discusses a patient who sustained a TBI from a motor vehicle accident and received neuro-optometric rehabilitation from a developmental optometrist and Integrative Manual Therapy™ with a physical therapist.

Case Summary: A 28-year-old Caucasian male was evaluated. For vision problems that started after he acquired a TBI during a car accident 11 years previous. He had numerous symptoms including reading difficulties, ocular pain, headaches, and difficulties with depth perception. The evaluation revealed binocular vision, accommodative, and oculomotor dysfunctions, as well as reduced peripheral visual awareness and visualization anomalies. Treatment included weekly office-based optometric vision therapy (OVT), home-based syntonics, primitive reflex integration, and single vision lenses with base-in prism. He also received Integrative Manual Therapy which began five months prior to the initiation of optometric intervention. At both a 1-month post OVT progress evaluation and by a telephone follow up 15 months post-OVT, the patient reported significant improvement in symptoms.

Conclusion: Patients with TBI secondary to motor vehicle accidents experience many detrimental quality of life changing vision symptoms. This case illustrates that improvement of symptoms and quality of life of a TBI patient are possible even 11 years after the initial injury.

Keywords: Traumatic Brain Injury, motor vehicle accident, Neuro-Optometric Rehabilitation, Optometric Vision Therapy, Integrative Manual Therapy, Syntonics, Primitive Reflex, Base-in Prism.

Background

The United States Center for Disease Control estimated that there are over 1.4 million traumatic brain injuries (TBI) in the United States each year.[1] Motor vehicle accidents were the cause of up to 20% of all TBI cases in adults and resulted in the highest number of hospitalizations. The most common causes of TBI are summarized in Table 1.[2] According to the United States National Highway Traffic Safety Administration, there were 5.8 million motor vehicle accidents in 2008 with a total of 1.6 million individuals injured.[3]

In a retrospective study of 160 TBI patients by Craig et al., the most prevalent vision symptoms reported were loss of balance (58.1%), dizziness (56.3%), eyestrain with near vision tasks (51.9%), and increased light sensitivity (49.4%), as well as headaches with near vision tasks (44.4%), near vision blur (43.8%), vertigo (28.1%), and motion sickness (7.5%).[4] Hellerstein et al. compared the visual symptoms of 16 TBI patients with 16 age-matched non-TBI patients.[5] The most prevalent vision symptoms found in the TBI patients were reading

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Table 1. The most common causes of TBI

Falls	28%
Motor vehicle accidents	20%
Struck by/against	19%
Assault	11%
Unknown	9%
Other	7%
Pedal cycle	3%
Other transport	2%

Table 2. Common vision symptoms reported by patients with TBI

Reading problems	Blur
Light sensitivity	Headaches
Balance/coordination problems	Dizziness
Eyestrain	Nausea
Diplopia	Vertigo
Motion sickness	

Table 3. Vision problems associated with TBI

Binocular dysfunction (esp. convergence insufficiency and strabismus)	Visual-motor dysfunction
	Visual-midline shift
Oculomotor dysfunction	Visual field defects
Accommodative dysfunction	Unilateral spatial inattention (visual neglect)
Myopia	Visual-vestibular dysfunctions/Postural difficulties
Visual-perceptual dysfunction	

problems (87.5%), blur (68.8%), light sensitivity (68.8%), and headaches (62.5%), as well as balance/coordination problems (56.3%), dizziness (37.5%), nausea (37.5%), diplopia (31.3%), and motion problems (12.5%). (Table 2 summarizes the common vision symptoms reported by patients with TBI.)

Vision dysfunctions are frequently seen in patients that have experienced a TBI. In a retrospective study of 160 TBI patients, Ciufffreda et al. found vision dysfunctions in 90% of the patients.[6] The most common were binocular vision dysfunction (56.3%), oculomotor anomaly (51.3%), accommodative dysfunction (41.1%), strabismus (25.6%), and cranial nerve palsy (6.9%). Suchoff et al. examined 62 patients with acquired brain injury from two extended care facilities.[7] Thirty-seven patients from this sample were noted to have sustained a TBI. The most common vision dysfunctions found were exo deviations (41.9%), oculomotor dysfunctions (39.7%), and visual-field defects (32.5%).

Other vision abnormalities reported in the literature for TBI patients include myopia,[8] visual-perceptual dysfunction,[9] visual-motor dysfunction,[10] visual-midline shift,[11] visual field defects,[12] unilateral spatial inattention[13] (visual neglect) and visual-vestibular dysfunctions[14-16] (See Table 3). Cognitive deficits are often observed as well. These may include anomalies in attention, concentration, perception, memory, speech/language, and executive functions.[17]

Optometric vision therapy has been reported to improve both vision symptoms and vision dysfunctions of patients with TBI.[18-24] Ciuffreda and Kapoor noted a 90% success rate in a group of 33 TBI patients after completing OVT over a period ranging from 2 to 8 months.[25] The criterion for success was measured improvement in at least one primary vision symptom and at least one primary vision sign. A sub-group of 9 patients with oculomotor-based reading problems was studied further.[26] All 9 subjects showed subjective improvement based on a reading symptoms scale and objective improvement based on the Visagraph® reading rate after therapy.

Neuroplasticity has been proposed as the mechanism of success for OVT and rehabilitation. Maino cited research describing a subtype of neuroplasticity called reparation plasticity that can occur during functional or structural recovery from damaged neuronal circuits in patients with TBI.[27] A literature review by Huang supports the concept that rehabilitation of motor, sensory, and cognitive impairment occurs by altering brain reorganization which results in functional recovery.[28] The principles utilized in neuro-optometric rehabilitation are described as inducing neuroplasticity through motivation, awareness of the process, feeling muscle tones, and task loading, as well as visualization, feedback, problem solving, repetition, and multi-sensory integration.

Syntonics have been utilized to reduce visual symptoms in patients with brain injuries.[29] The theory is that selected color wavelengths help enhance the balance of autonomic nervous system, the endocrine system, or both. Wallace, in a retrospective study of 46 patients (28 with head trauma and 18 with cerebral vascular accidents) at a brain injury rehabilitation center,[30] found that the most common vision findings were binocular dysfunction (96%), functional visual field constrictions (91%), and accommodative

Table 4. Commonly used optometric treatment modalities for patients with TBI

Optometric vision therapy	Binasal occlusion	Other sector occlusions
Plus lenses	Base-in prism lenses	Tinted lenses/overlays
Yoked prism lenses	Other prism lenses	
Syntonics	Primitive reflex integration	

dysfunction (89%). Other vision problems included oculomotor anomalies, amblyopia, and hemianopsia. All 46 patients were prescribed syntonics in the clinic at least one to four times a week for an average of 20 sessions. The most commonly prescribed colors were blue-green (mu-upsilon) and blue-indigo (upsilon-omega). Some patients also received binocular, accommodative, and/or oculomotor therapy. It was reported that 76% of the patients had significant improvement in binocularity, accommodation and oculomotor skills. Seventy percent of the patients were found to have functional expansions of the visual fields ranging from 20% to 500%.

Other commonly used optometric treatment modalities include plus lenses,[31] binasal occlusion,[32] other sector occlusions,[33] base-in prism,[34] yoked prism[35,36] and tinted lenses/overlays[37] (Table 4). Prisms which are typically prescribed for vertical deviations[38] and strabismus[39] can also be considered for patients who developed binocular dysfunctions after a TBI.

The concept of visually-related primitive reflex integration was first described in the optometric literature by Goddard.[40] The incorporation of primitive reflex integration techniques into an OVT regimen was demonstrated by Marusich at the College of Optometrists in Vision Development annual meeting in 2002.[41] The proposed theory is that failure of integration of these reflexes interferes with the development of more sophisticated, higher level skills of movement, balance, coordination, and voluntary control. A study of 22 children by Wahlberg and Ireland showed that primitive reflex integration of the Asymmetrical Tonic Neck Reflex improved oculomotor skills, reading fluency, balance, and the frequency of headaches.[42] Gonazalez et al. found a correlation between the oculomotor skills and primitive reflex integration of the Symmetrical Tonic Neck Reflex and Tonic Labyrinthine Reflex in children with learning problems.[43]

Integrative Manual Therapy consists of hands-on diagnostic and treatment techniques that are used to assess and treat structural dysfunctions of muscles, joints, tendons, bones, and connective tissues.[44] Techniques may involve methods to release tissue tension, relax muscle fibers, enhance joint mobility, and improve range of motion.[45] The premise of Integrative Manual Therapy is to locate the underlying cause of the dysfunction and restore the physiological balance of the body.[46] By achieving this goal, the body is allowed to heal itself and return to optimal functional ability.

CASE REPORT:
History

JS is a 28-year-old Caucasian male who is a graduate student majoring in philosophy. He was referred for a neuro-optometric evaluation by his wife who is a pediatric physical therapist working in the same clinic as the second author. His chief complaints were words move, shake, and flicker when reading, eyes hurt when he reads or drives, and occipital headaches while reading or driving. He also experienced poor depth perception when driving, chronic eye pain, and objects appear to vibrate. These vision problems started after he sustained a TBI secondary to a motor vehicle accident 11 years ago. His symptoms worsened this past year after he started graduate school. JS scored 50 on the COVD Quality of Life checklist[47] which suggested that significant visual problems were present.

The motor vehicle accident occurred on a country road while he was driving a sports utility vehicle. The car skidded, flipped as he overcompensated, and fell into a ditch. JS was unconscious for about 15 minutes and was transported to the hospital emergency room. He was diagnosed to have traumatic brain injury with frontal lobe swelling. Otherwise, no fractures were found and he was released the next morning. Since the accident, he experienced breathing discomfort with intense body exercise and frequent gastrointestinal irritations.

His last eye examination was approximately 3 years previous at which he was prescribed glasses for driving. His last physical examination was one week prior to this examination and the results were unremarkable. JS was born full-term with umbilical cord wrapped around his neck. He was receiving Integrative Manual Therapy for the past 5 months for a total of approximately 8 sessions from the second author who is a registered physical therapist.

The patient appeared to be able to move adequately within his environment. No apparent speech/language problems were present and he was actively engaged in many hobbies including playing guitar and drums, and auto-mechanics. He wanted to read more efficiently and comfortably, to drive with better confidence, and to see things without vibration.

Assessment

The examination findings are summarized in Table 5. The most significant findings included a large exo fixation disparity at near with a steep fixation disparity curve. Accommodative facility testing with either +/-2.00 or +/-1.50 flippers was not possible due to his difficulty clearing even the +1.50 DS lens. (An alternative facility assessment method was used by determining the highest plus lens JS was able to clear the near target starting with the +0.50 DS lens and then increasing this in 0.25 DS increments. The same procedure was repeated with the highest minus lens he could clear starting with the -0.50 DS lens.)

The Developmental Eye Movement Test (DEM) showed normal percentile scores. His pursuits and saccades scores in the NSUOCO Oculomotor Test[48,a] were the highest possible in all four areas (ability, accuracy, head movement, and body movement). However, during pursuit testing he reported eye pain in the superior and inferior gaze, more in the left eye than the right eye. Additional oculomotor anomalies were also noted by the Visagraph[b] Test.

The confrontational visual fields, visual-midline testing, clock test and line bisection test results were all unremarkable. The functional visual field showed normal color fields in the right eye but constricted in the left eye. Lenses and prism testing showed slight improvement in visual comfort with +0.50 DS each eye as measured by stress point retinoscopy. JS reported improved visual stability at distance with 0.5 prism diopters of base-in prism OU over his habitual glasses.

Primitive reflex screening of the Moro reflex showed that this reflex was not fully integrated. Balance was observed to be appropriate when walking in an office hallway. A slightly forward-leaning body posture was seen when walking. JS was right-handed and footed.

The Test of Visual Perceptual Skills (TVPS-3) showed above average scores in all subtests except a slightly below average score of 25th percentile in visual sequential memory. He scored below average on the Getman Visualization Test[a]. Visual-motor integration skills were informally assessed by observing the quality of his handwriting on the patient forms and his drawings on the clock test for unilateral spatial neglect. JS showed legible letter formation, adequate spacing, and a good ability to stay on the line. His expected level of performance on the written subtest of the Symbol Digit Modalities Test was another indication of average visual-motor quality and speed.

Physical Therapy/Integrative Manual Therapy Evaluation

JS received the initial physical therapy/Integrative Manual Therapy evaluation approximately 5 months prior to his optometric evaluation. At that time, he was found to have a normal gait, a tight and rounded posture and overall tight muscle tone at the back. During the Integrative Manual Therapy assessment, he was found to have bone bruising on the scalp in the frontal and parietal area, as well as in his left ankle. These were believed to be related to the motor vehicle accident. Bone bruising is a micro-fracture of the trabacula.[49] A therapist trained in Integrative Manual Therapy can detect bone bruising by physical palpation of the area above the bone. Tissue mapping assessment suggested tissue mobility changes at the ileocecal area which corresponded to his history of chronic gastrointestinal dysfunction since the accident. Clinic-based Integrative Manual Therapy was recommended for one session every 3 to 4 weeks along with home practice activities. Gluten-free diet (i.e., no wheat, barley, rye) was also suggested to minimize any gastrointestinal irritations. Food sources like rice, potatoes, and corn were allowed.

Diagnosis

The impression is that JS was suffering from vision dysfunctions secondary to the traumatic brain injury he sustained from the motor vehicle accident that occurred 11 years prior. His vision deficits included binocular, accommodative and oculomotor dysfunctions, reduced peripheral visual awareness, and visualization anomalies. Prognosis for improvement was expected to be good with neuro-optometric rehabilitation.

Table 5. Examination Findings

Pre- Testing in free-space (without correction)

Eye Dominance: right
Color Vision: normal

Extraocular muscles: unrestricted
NPC: 5 / 10 cm (break/recovery)
recovery reduced to 15 cm after 5 times

Hand Dominance: right
Stereopsis: 100” (lateral disparity), 250” (random dot stereopsis)
Amplitudes: OD/OS/OU: 8D/8D/12D
Fixation Disparity (Wesson Card):
9” to 16” exo, no vertical Fixation Disparity

Ocular Health

External and Internal: unremarkable

No signs of ocular trauma (dilation performed)

Refraction and Acuities

Visual Acuities (unaided):	OD 20/40	OS 20/50
Habitual Lenses:	OD -0.75 DS (20/20^{-1})	OS -1.00 DS (20/25)
Retinoscopy:	OD -1.25 -0.50 x 180	OS -1.25 -0.50 x 180
Subjective Refraction	OD -1.00 DS (20/20)	OS -1.25 DS (20/20)

Phorometry (through subjective refraction)

Phoria: Orthophoria / Orthophoria’
Distance: BO x/18/0 BI x/10/-1
PRA/NRA: -2.50D/+2.00D

Binocular Cross Cylinder: +0.50 DS Add
Near: BO x/12/-4 BI 12/18/0

Accommodative Testing

MEM: +0.50 DS OU (very dull reflexes)
Stress Point Retinoscopy: +0.50 DS OU

Accommodative Facility (through habitual distance Rx):
OD: can only clear up to +1.00/-2.00
OS: can only clear up to +0.50/-2.00
OU: can only clear up to +1.00/-1.00

Oculomotor Assessment

Developmental Eye Movement Test*
Vertical 60th percentile
Horizontal 70th percentile
Error 75th percentile
Ratio 75th percentile

Visagraph®
Grade equivalent: 9 to13
Comprehension: 80%
Oculomotor Anomalies:
Increased number of fixations
Increased duration of fixation
Reduced span of recognition
Reduced reading rate

NSUOCO (Maples) Oculomotor Test
Saccades
Ability 5
Accuracy 5
Head Movement 5
Body Movement 5
Pursuits
Ability 5
Accuracy 5
Head Movement 5
Body Movement 5

Neuro-optometric Testing

Confrontational Visual Field:
OD: normal, no extinction phenomenon
OS: normal, no extinction phenomenon
Visual-Midline: no vertical or horizontal shift
Unilateral Spatial Inattention testing:
Clock Test: normal
Line Bisection Test: normal
Primitive Reflex Screening:
Moro Reflex: not integrated
Response to Lenses
Binasal Occlusion: no improvement
Plus lenses: slight improvement w/+0.50 DS OU
Base-in Prisms: improved visual comfort w/0.5 BI OU
Tinted Lenses: slight improvement w/Blue Pink No.1
Overlays: slight improvement w/pink

Functional Visual Field (Color Field):

OD	White field:	27 to 33 degrees (normal)
	Green field:	15 to 18 degrees (normal)
	Red field:	18 to 21 degrees (normal)
	Blue field:	21 to 24 degrees (normal)
	Blind spot:	normal
OS	White field:	30 degrees (normal)
	Green field:	Over 18 degrees (normal)
	Red field:	4 to 11 degrees (constricted)
	Blue field:	15 degrees (constricted)
	Blind spot:	normal

Table 5. Examination Findings – ***Continued***

Visual-Perceptual		**Cognitive Screening**	
Test of Visual-Perceptual Skills (TVPS-3)**		Symbol-Digit Modality Test: 49 (mean±SD = 51±11.5)	
Visual Discrimination	50	Test of Auditory Perceptual Skills (TAPS-R)***	
Visual Memory	91	Auditory Number Memory:	
Visual Spatial Relationship	63	Forward: 77%	
Visual Form Constancy	84	Reverse: 73%	
Visual Sequential Memory	25	Griffin Dyslexia Determination Test[b]	
Visual Figure Ground	98	Word Decoding: College Level	
Visual Closure	75		
Getman Visualization Test	6 / 12		

Notes:
* Percentile scores based on the DEM ceiling age of 13.11 years old
**Percentile scores calculated based on the TVPS-3 ceiling age of 18.11 years old
***Percentile scores calculated based on the TAPS-R ceiling age of 13.0 years old

Table 6. Home-based Vision Activities

Visual Hygiene (Week #1-20)	Syntonics (Week #1-4)	Primitive Reflex (Week #2-20)	Computer Activities (Week #13-17)	Other Home Activities (Week #5-20)
Posture	Blue-green (mu-upsilon)	Toes-in Walk	HTS software	Hart Chart Saccades
Breathing	20 minutes/day x 4 weeks	Toes-out Walk		Hart Chart (Near-Far)
Peripheral awareness				Brock String
Relaxing mind				Lifesavers Cards (Clear/Opaque)

Treatment Plan

JS was prescribed single vision plastic lenses with anti-reflective coating: OD -1.00 DS 0.5 BI prism and OS -1.25 DS 0.5 BI prism for driving. It was recommended that he receive in-office optometric vision therapy once a week, for 50 minutes, for 20 to 40 sessions. Home vision therapy would include syntonics, primitive reflex integration, and other visual activities.

Other treatment options that might have been considered included plus lenses, tinted lenses/overlays, and base-in prisms for near use. These were not prescribed because JS indicated that he desired wearing glasses for the least amount of time and would rather participate in a therapy program that would aim at treating the underlying cause.

Neuro-Optometric Rehabilitation

The home-based vision activities are summarized in Table 6. Syntonics was prescribed due to the constricted functional color fields of the left eye. It was recommended that JS use the Syntonizer[b] unit with the blue-green (mu-upsilon) filter for 20 minutes a day in a dark room without glasses for 4 weeks. This color is often prescribed for patients with headaches and pain related to trauma.[50]

Primitive reflex integration was recommended to be practiced at home. The reflex pattern to be integrated was the Moro reflex. This consisted of walking forward and then backwards without shoes with his toes pointing in and with his hands on his sides. As he became more proficient, he would perform the movement with a closed fist and his thumbs pointing out. Similarly, he was asked to walk with his toes pointing out and with his hands on his sides. As he became more adept at this task, he would perform this movement with a closed fist and the thumbs pointing in.

The HTS computer software[c] was prescribed for use at the 13th week of in office therapy to provide home therapy for his binocular, oculomotor, and accommodative dysfunctions. JS practiced the HTS program diligently on a daily basis and was able to complete this program by the 17th week. His office-

Table 7. Office-Based Vision Therapy

Multi-sensory	Binocular	Oculomotor	Accommodative
Bean Bags on Belgau Balance Board[d]	Quoits Vecto w/ Bernell No.9	Marsden Ball	Monocular Hart Chart
Slap-Tap w/ Visual Motor Series[51] 1A Chart	Clown Vecto	Space Fixator	Monocular Lens Rock:
Slap-Tap w/ Visual Motor Series 1B Chart	Chicago Vecto	Hart Chart Saccades	+/-0.75 to +/-2.50
Slap-Tap w/ Visual Motor Series 1C Chart	Brock String	Saccades Workbook	Monocular Training in
Randolph Shuffle[52] w/Letter Chart	3-Dot Card	Michigan Tracking	Binocular Field:
Randolph Shuffle	Aperture Rule Trainer (Single)		+/-1.00 to +/-2.50
w/ Letter Chart and metronome	Aperture Rule Trainer (Double)		Bi-ocular Lens Rock:
	Lifesavers Cards (Opaque)		+0.75/-1.50 to +2.50/-5.00
	Lifesavers Cards (Clear)		Binocular Lens Rock:
			+/-0.25, 0.50

based vision therapy was focused on four main areas: multi-sensory, binocular skills, oculomotor skills and accommodative skills (see Table 7). With the multi-sensory therapy, techniques were performed to enhance visual-vestibular, bilateral, and visual-auditory integration.

Binocular therapy was performed using vectograms, the Brock string, 3-Dot card, Life Saver Cards and aperture rule. The overall approach was to first improve slide vergences, then jump vergences, and finally chiastopic/orthoptic fusions. These therapy procedures were used to enhance SILO awareness, localization, depth perception, and vergence ranges, as well as binocular fusion, physiological diplopia awareness, anti-suppression, and vergence facility. The Life Saver Cards were used to improved vergence in free space.

The oculomotor therapy was first performed monocularly and then with both eyes. This oculomotor therapy included the Marsden ball, Space Fixator[a], Hart Chart saccades, the use of a saccades workbook and Michigan tracking. Accommodative therapy was performed in a stepwise approach starting with monocular, moving to bi-ocular, and finishing with binocular therapy procedures.

JS received a total of 13 sessions of Integrated Manual Therapy every 3 to 4 weeks. There were approximately 8 sessions of therapy prior to the start of his neuro-optometric rehabilitation and 5 sessions concurrent with his optometric vision therapy. Each session was almost 1 hour in length. The Integrated Manual Therapy techniques involved were bone bruising techniques, myofascial release[45], and Neurofascial Process™.[53]

The bone bruising technique was used to bring the two sides of the bones together smoothly and evenly to heal the micro-fracture of the trabecula that was caused by the injury. This was done on the cranium and left ankle where bone bruising was found during the initial Integrative Manual Therapy evaluation. During his treatment sessions, further bone bruising was identified and treated in the hip area. The myofascial release technique was used to relax the tension within the connective tissues. This was performed at the following locations by applying gentle forces from outside the body: (1) the pelvis diaphragm area on each side of the hip, (2) the thoracic diaphragm area around the bottom of the rib cage, (3) the respiratory area below the armpit on each side, (4) the cranial diaphragms on each side of the head , (5) the subclavius areas on each side below the clavicles, and (6) the lower back area at the tissues area behind the ureter.

He received approximately 20 minutes per day of Neurofascial Process at home using tactile technique to relax the tissues, to improve circulation, and to enhance metabolism. This was accomplished with the help of the patient's wife who is a pediatric physical therapist. Her palm was placed gently in front of one of his closed eyelids and the other palm was first placed in front of his chest area outside his heart and then at his back corresponding to the soft tissues outside the ureters.

Progress Evaluations

(See Table 8 for a summary of the key findings before, during, and after optometric vision therapy.) At the progress evaluation performed at week 5, he reported improvement in symptoms. JS noted that he was able to read longer and visually track better. The words were not shaking or moving as much and he was experiencing less eye pain. The key findings

Table 8. Key Findings Pre and Post Neuro-Optometric Rehabilitation

	Baseline (Pre-therapy)	1 month (Week #5)	2.5 months (Week #10)	3.5 months (Week #14)	6 months (Week #20)	7 months (1 Month Post)
NPC (break/recovery)	5/10 cm	4/8 cm	To-the-nose	4/6 cm	To-the-nose	To-the-nose
NPC (after 5 times)	5/15 cm	4/8 cm	To-the-nose	6/8 cm	To-the-nose	To-the-nose
BO ranges (distance)	x/18/0	x/12/0	x/4/2	x/20/8	x/14/2	x/6/2
BI ranges (distance)	x/10/-1	x/2/-2	x/2/1	x/12/8	x/16/0	x/4/0
BO ranges (near)	x/12/-4	x/12/2	x/14/10	14/16/6	x/30/4	14/30/15
BI ranges (near)	12/18/0	x/10/2	x/8/4	x/12/2	x/18/0	x/10/2
Accom. amplitude (OD)	8 D	10 D	20 D	20 D	20 D	12.5 D
Accom. amplitude (OS)	8 D	10 D	20 D	20 D	20 D	12.5D
Accom. amplitude (OU)	12 D	12 D	20 D	20 D	20 D	17.5 D
Pursuit (NSUOCO)	Painful	Less pain	Not tested	Not tested	No pain	No pain

included improvement in near point of convergence and accommodative amplitude. During pursuit testing with the NSUOCO oculomotor test JS noted much less pain.

At the progress evaluation (week 10), he could read for up to 3 hours a day with minimal word shaking or flickering. He was also able to drive with improved confidence. At this visit, JS also requested resuming syntonics because he felt that he was achieving the most relief and progress when syntonics was done. The findings at this time included further improvement of the near point of convergence and accommodative amplitude.

At the progress evaluation on week 14, JS mentioned he was very busy and tired because his wife just gave birth to a baby boy 3 weeks prior. Otherwise, his visual symptoms had remained stable since week 10. We noted improvement in vergence ranges as well.

By week 20, JS could read longer and more often. His eye pain was greatly reduced and it was easier to see small objects during grocery shopping. He was also driving with increased confidence and further improvement in his vergences ranges were seen. During pursuit testing using the NSUOCO oculomotor test, there was no pain at all. About this time, JS notified us that he would soon be relocating back to his home state and therefore would discontinue his in-office vision therapy. He was also planning to start a new career as a life insurance agent.

At the 1-month post-therapy progress evaluation, he reported being very busy between taking care of the baby and planning for the relocation and that he was very happy with all of the improvements gained. The key findings included maintenance of the improved near point of convergence, improved base-out ranges at near, and pursuits (NSUOCO) without pain. The base-out range at distance, the base-in range at distance, the base-in range at near, and the accommodative amplitude were somewhat reduced compared to one month prior however.

We recommended that JS continue his vision care with a developmental optometrist in his home state. It was likely that he could benefit from additional optometric vision therapy to further improve his visual skills. In the mean time, we recommended that he practice the Brock string, the opaque Lifesaver Card and the monocular Hart chart near-far as maintenance visual activities approximately two to three times per week.

JS concurred that his quality of life had improved by noting that he now had the hope and the desire to learn new things that were previously difficult to do. He reported that he was able to track and scan objects better than ever done before. Tasks like finding small objects in a store were no longer cumbersome. He was also driving and reading with greater ease. In fact, it would have been impossible for him to consider the work of a life insurance agent with all the reading of contracts and small print that would have been visually overwhelming before treatment.

During a phone conversation 15 months post-therapy, JS reported stable vision and that he was working as a financial advisor. He mentioned that when studying for the financial advising and life insurance licensing examinations, he needed to read for up to 60 hours per week. JS commented that words had not been shaking and he was able to pass both examinations. Occasionally, he experiences mild headaches and ocular pain whenever he has digestive problems. He receives treatment for this from a naturopathic practitioner.

The COVD Quality of Life checklist was completed over the phone with a total symptom score of 28. This indicated a significant decrease in symptoms and increased in quality of life as compared to the pre-therapy score of 50. JS mentioned that due to his busy work and family schedule he had not received any vision care since he was last seen at our office. I again recommended that he follow up with a developmental optometrist in his area.

Table 9. Resources for Neuro-optometric Rehabilitation

College of Optometrists in Vision Development (COVD)	www.covd.org
Neuro-Optometric Rehabilitative Association (NORA)	www.nora.cc
College of Syntonics Optometry (CSO)	www.syntonicphototherapy.com
Optometric Extension Program Foundation (OEPF)	www.oepf.org

Discussion

The case report highlights the use of a program of neuro-optometric rehabilitation consisting of office-based optometric vision therapy, home-based syntonics, home-based primitive reflex integration, and single vision lenses with base-in prism along with concurrent Integrative Manual Therapy. This patient noted reading difficulties, ocular pain, headaches, and depth perception problems since the motor vehicle accident. The symptoms appeared to worsen when he began graduate school, where an increased visual demand in reading was required. The end result was significant relief of his symptoms as well as improvement of his functional vision findings. The positive outcome obtained was very encouraging to the patient since he had suffered the problems for 11 years and thought that nothing could be done. Due to the longstanding nature of the problems, the improvement is not likely due to spontaneous recovery, but much more likely due to the therapeutic interventions he received.

The mechanism of traumatic brain injury resulting in vision deficits is believed to be due to damage of either the vascular supply or nerve endings.[54] It may involve damage to the small blood vessels that supply the areas of the central nervous system involved in oculomotor control. Further, there may also be damage to the nerve endings of the peripheral nerves due to the axonal shearing and stretching forces that occur in areas near the third, fourth, and sixth cranial nerves.

The home-based syntonics treatment was a vital element in relieving his vision symptoms, especially since his ocular pain improved concurrently over the first four weeks of his rehabilitation. The patient also discovered by the end of the second week of syntonics that 25 minutes per day of treatment instead of typical treatment 20 minutes per day appeared to provide even more relief.

It is the first author's belief that the syntonics treatment provided positive biochemical changes in the autonomic nervous system that calmed down the instability and fluctuations in his visual system. Once the incoming visual input became stable, the binocular, oculomotor, and accommodative therapy allowed the patient to develop the necessary coordination to perform various visual tasks with comfort, efficiency, flexibility, and stamina.

If this patient had not needed to relocate with such haste, a re-evaluation including the COVD quality of life checklist, the Visagraph, fixation disparity, and the functional visual fields for pre- and post-therapy comparisons would have been conducted. Since the vision findings at the one-month post-therapy evaluation showed a decrease in vergence ranges and accommodative amplitudes as compared to one month prior, JS could probably benefit from further neuro-optometric rehabilitation to solidify his binocular and accommodative skills as well as to improve his visualization skills. One other recommendation that could have been considered was a consult with the disability student counselor at his academic institution. The counselor might have been able to arrange for accommodations such as visual breaks and extended time for tests, as well as any assistive technology that could have been helpful in his academic pursuits.

Conclusion

This case report illustrates the improvement of vision symptoms, signs and the quality of life of a patient who suffered from severe chronic vision problems caused by a TBI. Optometric evaluation identified the vision dysfunctions present. This resulted in an appropriate treatment being instituted and positive outcomes. Since TBI secondary to motor vehicle accidents are highly prevalent, we recommend that all practicing optometrists, optometric educators, residents, and students familiarize themselves with the available neuro-optometric diagnostic protocols and treatment modalities. (Refer to Table 9 for resources on neuro-optometric rehabilitation.)

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Equipment Sources

a Optometric Extension Program
1921 E. Carnegie Ave., Ste. 3-L
Santa Ana, CA 92705
www.oepf.org

b Bernell Corporation U. S. Optical Division
Vision Training Products, Inc.
4016 N. Home St.,
Mishawaka, IN 46545
www.bernell.com

c HTS Inc.
6788 S. Kings Ranch Rd. Ste. 4
Gold Canyon, AZ 85188
www.homevisiontherapy.com

d Balametrics Inc.
P.O. Box 2716
Port Angeles, WA 98362
www.balametrics.com

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