Article • Vision Therapy for Oculomotor Dysfunctions following Mild TBI: A Case Report

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ABSTRACT

Background: Oculomotor dysfunctions are common visual problems following mild traumatic brain injury (TBI). They not only produce vision discomfort and possible loss of visual efficiency, but they may also negatively affect the overall rehabilitative process. It is important for clinicians to be aware of the visual symptoms and the possible treatments for oculomotor dysfunctions.

Case Report: A 44-year-old TBI patient with complaints of blurred near vision, visual discomfort, and reduced peripheral vision was examined. He was diagnosed with fusional vergence dysfunction and saccadic dysfunction. The treatment consisted of eight in-office vision therapy sessions every one to two weeks and daily home exercises. The post-treatment examination showed increased vergence ranges, improved stereopsis, and better saccadic function. The patient reported a reduction in visual complaints.

Conclusion: This case report indicates that office-based vision therapy is effective in reducing visual symptoms and improving oculomotor dysfunctions after mild traumatic brain injury.

Keywords: eye movements, oculomotor dysfunction, oculomotor training, traumatic brain injury (TBI), vergence, vision therapy

Introduction

Over the past two decades, there has been increased interest in the treatment of mild traumatic brain injury within optometry.[1] Motor vehicle accidents, falls, and assaults are the most common causes of traumatic brain injury.[2] The Centers for Disease Control and Prevention[3] define traumatic brain injury (TBI) as "an injury that disrupts the normal function of the brain. It can be caused by a bump, blow, or jolt to the head or a penetrating head injury."

Classification of Traumatic Brain Injury

Based on the patient's neurological signs and symptoms, a TBI is classified as mild, moderate, or severe. According to the U.S. Centers for Disease Control and Prevention,[4] the definition of mild traumatic brain injury (mTBI) is:

> an injury to the head as a result of blunt trauma or acceleration or deceleration forces with one or more of the following conditions: any period of observed or self-reported transient confusion, disorientation, or impaired consciousness; dysfunction of memory around the time of injury; loss of consciousness lasting less than 30 minutes; or observed signs of neurological or neuropsychological dysfunction, such as seizures acutely following injury to the head; irritability, lethargy, or vomiting following head injury; headache, dizziness, irritability, fatigue, or poor concentration.

Mild TBI or concussion is caused by the rapid acceleration of the brain, which has an impact on the inner walls of the skull. This can cause focal lesions such as cerebral laceration and hemorrhage and more diffuse damage resulting in oedema and diffuse axonal injury.[5]

Visual Symptoms Following Traumatic Brain Injury

The most common visual consequence of mTBI is post-trauma vision syndrome (PTVS).[6] PTVS can include signs such as ocular motor deficits, convergence insufficiency, high exophoria or exotropia, accommodative dysfunction, low blink rate, difficulties in attention, and visual-spatial disorientation (Table 1).[6]

This case report focuses on the oculomotor dysfunctions after mild TBI. The oculomotor system is

Table 1. Oculomotor and Visual Symptoms in TBI[12]

Symptoms
Avoidance of near tasks
Oculomotor-based reading difficulties
Eyestrain
Eye tracking problems
Eye focusing problems
Diplopia
Vertigo
Dizziness
Vision-derived nausea
Visual inattention and distractibility
Increased sensitivity to visual motion
Difficulty with global scanning
Difficulty judging distances
Short-term visual memory loss
Difficulty with personal grooming
Inability to cope visually in a complex social situation (e.g., minimal eye contact)
Inability to handle complex visual environments

an important area of concern in mild TBI. In a study by Ciuffreda et al.,[7] 51.3% of the patients with TBI presented with a versional oculomotor dysfunction: there were deficits in fixation, saccades, smooth pursuits, or the vestibulo-ocular reflex (VOR). The high frequency of oculomotor problems makes sense, as three of the 12 cranial nerves deal directly with fine oculomotor control, and a fourth cranial nerve deals with oculo-vestibular function.[8]

Saccades can be altered after mild TBI. Releasing attention from one visual target or locking onto another one can be difficult. Patients may also show slow saccades and undershoots.[9] Reddy et al.[10] measured the reading eye movements in TBI patients using the ReadAlyzer. Subjects with TBI presented an increased number of fixations and regressions and a reduced reading rate.

The vestibular system plays an integral role in controlling balance, spatial orientation, and stable vision. The vestibulo-ocular reflex (VOR) serves to maintain stable vision during head movement. Dizziness is the second most-reported concussion-related symptom following headache.[11] An abnormal VOR causes illusory movement of the text and the surrounding environment when head movement occurs during reading.[12]

Ciuffreda et al.[7] found convergence insufficiency to be present in 42.5% of the TBI patients. Binocular instability, characterized by restricted vergences, was found to be 10%. Convergence insufficiency is associated with asthenopia, fatigue, difficulty concentrating on near point tasks, diplopia, and reading difficulties.[6]

Oculomotor dysfunctions in TBI

According to Ciuffreda et al.,[7] most individuals with either TBI or cerebral vascular accident (CVA) show some type of oculomotor dysfunction. The five categories of oculomotor dysfunction investigated were accommodation, version, vergence, strabismus, and cranial nerve palsy. Accommodation deficits (41.1%) and vergence deficits (56.3%) were more prominent in the TBI group. In the CVA subgroup, strabismus (36.7%) and cranial nerve palsy (10%) were more prominent. The frequency of versional deficits was similar in each subgroup (approximately 55%). When assessed across the five categories, 90% of the TBI subgroup manifested some type of oculomotor dysfunction.

Oculomotor signs in TBI are receded near point of convergence, restricted fusional vergence ranges at far and near, reduced relative accommodation, reduced amplitude of accommodation, increased lag of accommodation, slowed accommodative facility, abnormal Developmental Eye Movement test results, low performance on the Visagraph/ReadAlyzer, and impaired versional ocular motility.[12]

Oculomotor dysfunctions do not only produce vision discomfort and possible loss of visual efficiency, but they may also negatively affect the overall rehabilitative process. For example, cognitive rehabilitation and speech/language rehabilitation involve accurate fixation, saccadic visual search, and visual scanning exercises.[7]

Case Report

A 44-year-old male presented in August 2022 with a history of TBI. In March 2020, a tree fell on his head, leading to skull fracture and retinal hemorrhage. There was a temporal field loss in the right eye caused by the accident. Figure 1 shows the patient's perimetry results before the accident. Figure 2 shows the visual field loss after the accident.

Static visual acuity was measured with a Snellen chart at distance and near. To assess the VOR, dynamic visual acuity was measured at distance. The patient was instructed to read the lines from the Snellen chart while moving his head from side to side. If the difference between the static and dynamic visual acuity was greater than 2 lines, it indicated a bilateral vestibular issue.[11]

Refractive error was determined with distance retinoscopy. Subjective refraction was performed with a phoropter.

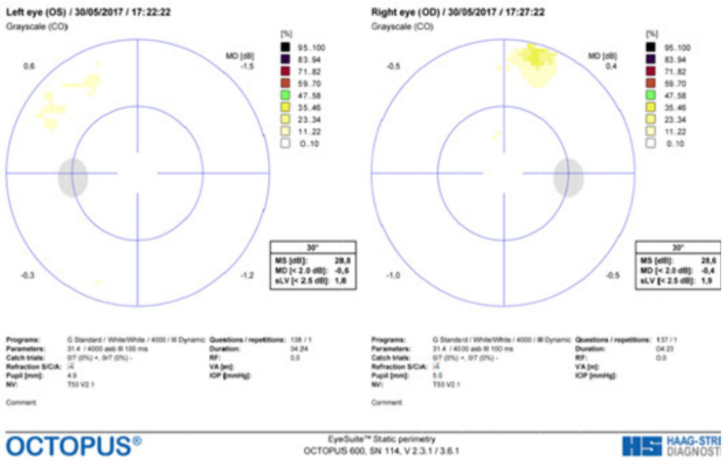

Figure 1. Perimetry results before the accident occurred

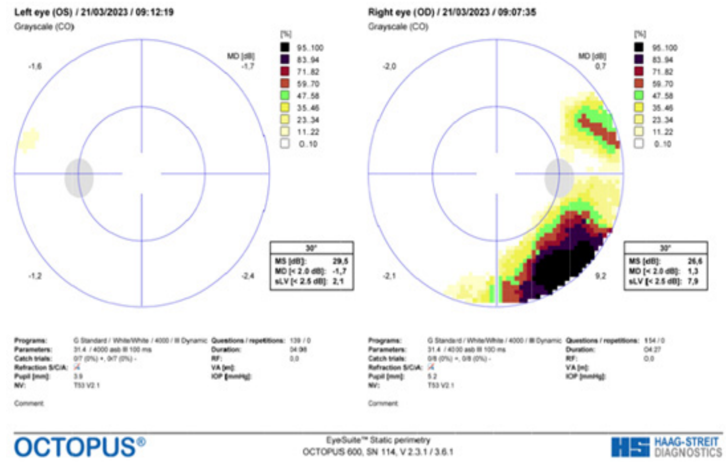

Figure 2. Perimetry results after the accident, showing a temporal field loss

Ocular alignment/phoria at distance and near was measured with the cover test and the von Graefe technique in a phoropter. Near point of convergence was evaluated with a penlight. Smooth positive and negative fusional vergences at distance and near were measured with Risley rotary prisms in a phoropter. Fusion at distance and near was tested with the Worth 4-dot test.

Stereopsis at near was evaluated with the Stereo Optical Stereo Tests. The butterfly stereo test is a gross stereopsis test with 2500 to 1200 arc seconds of disparity. Three rows of animal pictures present 400, 200, and 100 arc seconds stereoscopic disparity. The Wirt Stereotest presents nine diamonds, each of which contains four circles. One of the circles stands out.[13] Eye movements were evaluated with the Maples Oculomotor test and the King-Devick test.

Near tests were performed at 40 cm. Because of the age of the patient, accommodative facility was not included in the optometric examination. The optometric test results from the initial evaluation are listed in Table 2. It shows that visual acuity was excellent both at distance and near. There was only a small reduction in dynamic visual acuity, indicating a normal VOR. The patient showed a slight hyperopia. There was no phoria present, and the Worth 4-dot test showed normal fusion at distance and near. Near point of convergence was very strong.

Pre-therapy positive and negative fusional vergence ranges at distance and near were reduced. The patient was diagnosed with fusional vergence dysfunction. Gross saccades and smooth pursuits were good pre-therapy; however, the patient scored in the 5th percentile on the King-Devick test. It took him 58.2 seconds to complete the test. He was diagnosed with a saccadic dysfunction.

Table 2. Pre-therapy Optometric Test Results

Clinical measure	Initial exam
Static distance visual acuity	OD: 20/12.5
	OS: 20/16
	OU: 20/12.5
Dynamic distance visual acuity	OU: 20/16
Near visual acuity	OU: 20/20
Cover test distance	Orthophoria
Cover test near	Orthophoria
Retinoscopy	OD: +0.75
	OS: +1.00
Subjective refraction	OD: +1.00-0.25x075
	OS: +1.50-0.75x105
Distance phoria	0.5 XP
Near phoria	2 XP
Positive fusional vergence distance	x/6/4
Negative fusional vergence distance	4/2
Positive fusional vergence near	x/6/4
Negative fusional vergence near	x/5/4
Wirt circles Stereo Optical Stereo Test	6 (80 arc seconds)
Gross saccades (Maples)	Good
Gross pursuits (Maples)	Good
NPC	3 cm
Worth 4-dot distance	4
Worth 4-dot near	4
King-Devick	58.2 sec / 5th percentile

In addition, the Brain Injury Vision Symptom Survey (BIVSS) was administered to monitor changes in symptoms. The BIVSS is a validated, self-administered survey for TBI-related vision symptoms. It consists of 28 items to query vision-related behaviors. It uses a five-point Likert scale (Never, Seldom, Occasionally, Frequently, Always).[14] The patient suffered most from blurred near vision, fluctuating vision, eye discomfort, headaches and dizziness after using his eyes, lack of confidence walking/missing steps/stumbling, distorted side vision, and short attention span when reading. The patient scored 29.

Treatment

The patient received office-based oculomotor vision therapy administered by a neuro-optometrist during a 30-minute office visit every one to two weeks, combined with daily home procedures for a minimum of 10 minutes.

The treatment used was based on the Six Eye Exercises (SEE) protocol previously used by Berryman et al. The SEE protocol reflects a bottom-up approach to oculomotor treatment. It includes six exercises: eye stretches, saccades, tracking, vergence, gaze stabilization, and spatial localization.[15] In addition, peripheral vision was incorporated. The duration of vision therapy was determined based on experience and the evolution of the visual complaints of the patient. The patient did not wear any optical correction during the treatment. The therapy procedures used in each session are listed in Table 3.

Table 3. Office-Based Therapy Procedures

Session	Visual skill	Procedure
Session 1	VOR	Doll's eye
	Saccades	Hart chart
	Ocular alignment	Brock string (short)
Session 2	VOR	Gaze stabilization
	Saccades	Book fixations (reading text)
	Fusional vergence	Tranaglyphs
	Smooth pursuits	Marsden ball
Session 3	Smooth pursuits and convergence	Coin Circles
	Saccades	Stick trainers/alphabet pencils
	Ocular alignment	Brock string (long)
	Smooth pursuits	Marsden ball on balance board
	Fusional vergence	Bioptograms BO
Session 4	VOR	Infinity walk
	Saccades	Saccadic workbook level 1
	Fusional vergence	Sports cards BO
	Fusional vergence	Quoits vectogram
Session 5	Saccades	Saccadic exercise level 2
	Ocular alignment	Brock string: loading
	Fusional vergence	Sports cards BI
	Fusional vergence	Vectograms distance
Session 6	Smooth pursuits	Eye control
	Saccades	Lecocq 1 – 50
	Fusional vergence	VIP savers BI
	Saccades/vestibular	Blazepods R/G on balance board
Session 7	VOR/smooth pursuits/peripheral vision	Juggling: 3 different ways
	Fusional vergence	Brock string with prism flipper
	Peripheral vision	MacDonald chart
Session 8	Saccades/accommodation	Counting stars distance – near
	Fusional vergence	3 figure plate with prism flipper
	Fusional vergence	Cat card

VOR Procedures

Therapy procedures with head movement were integrated in the rehabilitation program to improve VOR function. In the doll's-eye exercise, the patient fixated an object while rotating his head. On a higher level, gaze stabilization was performed. In gaze stabilization, the patient was reading a Hart chart while rotating his head.

The infinity walk procedure was used to train multiple visual skills, such as VOR and peripheral awareness. The patient had to walk a figure eight pattern between two obstacles, keeping eyes on a visual target.

Juggling was an exercise performed in different ways, each with a purpose. To improve VOR function, the patient threw a ball from one hand to the other while following the movement of the ball by moving his head.

Procedures for Saccadic Function

Vision therapy procedures for saccadic function were first performed monocularly. When performance improved, the exercises were done binocularly.

In the Hart chart exercise, the patient was asked to read the first and last letters in each row, then the second and next-to-last letters, then the third and third-from-last letters, and so on. As ability improved, the patient was instructed to read the chart in time with a metronome.[13] The book fixations were used to train both saccades and fixation in a context similar to reading. The patient held a page with several rows of sentences. He called the first word in line one, maintained fixation for 3-5 seconds, and then made a saccade to the last word in line one, calling it out and maintaining fixation. This continued down the lines of text. Later, the rate of change was increased. With further progress, the patient made a saccade to the first and last letter of each line.[12]

Stick trainers and alphabet pencils were used to train saccadic movement. Two pencils with symbols or letters were held in front of the patient, about 30 cm apart. The patient was asked to read a symbol/letter alternately from each pencil, from top to bottom.

In the saccadic workbook level 1, the patient was instructed to read the underlined numbers aloud. To increase the difficulty of the task, a metronome was added. Saccadic exercise level 2 consisted of a sheet with two rows of numbers, one on the left side of the sheet, the other on the right. The patient had to read the numbers aloud, from left to right and from top to bottom.

The Lecocq 1 – 50 exercise consists of a sheet with numbers from 1 to 50. The patient was instructed to tap the numbers in the correct order as quickly as possible.

Counting stars distance – near was performed to train both saccades and accommodation. A sheet hanging on the wall contained groups of stars. The patient held an identical but smaller chart at arm's length. He had to count how many stars each group contained, alternately counting a group at distance and the next group at near.

When performance on saccadic exercises improved, difficulty was increased using BlazePods on a balance board. BlazePods are lights that flash in different colors. Red and green lights were used in combination with red/green glasses to create dissociation. The patient was standing on a balance board and tapped the red and green lights on the wall as quickly as possible.

Procedures for Smooth Pursuits

Vision therapy procedures for smooth pursuits were performed monocularly and binocularly. A Marsden ball with letters affixed was hung from the ceiling at eye level. The patient tracked the ball in its rotational, lateral, or near-distance movement.[13] To increase difficulty, the patient was asked to stand on a balance board while tracking the ball.

Coin circles were performed with a coin. The patient held a coin at eye level and made a vertical circle with it, followed by a horizontal circle and a figure eight, keeping the eyes on the coin during its movement. The goal of this exercise was to improve both smooth pursuits and convergence.

In the eye control exercise, the patient interlocked his fingers, except for the index fingers, which remained straight. He maintained his fixation on the index fingers as they moved diagonally and in a cross shape. It was a procedure for smooth pursuits on a relatively short fixation distance.

To improve smooth pursuits with a juggling exercise, the patient was instructed to throw a ball from one hand to the other without moving his head. He had to follow the movement of the ball with his eyes alone.

Ocular Alignment Procedures

Brock strings of 3 m (long) and 50 cm (short) with 3 movable beads at different fixation distances along the strings were used. The strings were seen in physiological diplopia by the patient, and they appeared to cross at the fixation point. The Brock string provided feedback regarding the accuracy of binocular fixation. The point at which the patient saw the strings cross is that at which the eyes were actually pointing. Loading techniques for the Brock string included training in different directions of gaze and increased speed of jump vergence procedures.[13]

Fusional Vergence Procedures

Bioptograms, manufactured for use in a Brewster stereoscope, were applied to improve fusional vergence ranges. In this case, the base-out series was used. Some cards had a step vergence effect, while others had a jump vergence demand.[16]

Polaroid vectograms were also used for fusional vergence training. For this patient, the Quoit vectogram was used. The Quoit vectogram presents only a little fusion lock. The goal was to sustain fusional vergence even in the presence of weak stimuli.[13] Polaroid vectogram training was begun at near. As performance improved, distance was extended. The same technique was used with the tranaglyphs, which are red/green anaglyphs used for fusional vergence training. In comparison to vectograms, red/green anaglyphs are weak stimuli for fusion. They also present brightness differences that may interfere with fusion.[13]

The main purpose of the sports cards, which are an example of chiastopic fusion cards, was to increase fusional convergence or divergence and to monitor suppression during motor fusion stress. It is an excellent technique for enhancement of open-space fusion skills.[17] The VIP savers consist of two cards that are moved apart to increase the convergence or divergence demand in free space. The cat card was also used as a stereogram exercise to develop fusional vergence in free space. The patient started the exercise in base-out at arm's length and increased distance as far as possible.

The Brock string in combination with prism flippers was used to train vergence flexibility. Prism and lens flippers were added to the Brock string to develop flexibility between accommodation and convergence.[13] Another procedure to enhance vergence flexibility was the three-figure plate in combination with a prism flipper. The three-figure plate consists of one red circle, one blue-green circle, and one white circle, each with a black drawing in it. The procedure was performed with red/cyan glasses.

Procedures for Peripheral Vision

To increase awareness of peripheral vision, the patient was asked to juggle without head or eye movements. He threw a ball from one hand to the other while fixating a distant object.

Another procedure for peripheral vision was the MacDonald form field card. The MacDonald card consists of a central fixation dot surrounded by letters. The patient fixated the dot and tried to maintain awareness of as many of the surrounding letters as possible.[13]

Results

The time between the accident and the first assessment was 2 years 5 months. The second optometric evaluation was 2.5 months later. In this period, eight sessions of vision therapy took place.

Visual Symptoms

The results of the pre-therapy and post-therapy BIVSS are listed in Table 4. The total score for all 28 items pre-therapy was 29. After 8 sessions of vision therapy, the total score was 9. This shows that the patient experienced far fewer symptoms after therapy.

The problems in peripheral vision were due to the retinal hemorrhage that occurred during the accident, which led to visual field loss. This could not be treated with vision therapy. However, the patient did not experience many disadvantages of his visual field loss in daily life.

The patient experienced most of his symptoms in the areas of eyesight clarity and visual comfort. Vision therapy had the most effect on these visual behaviors. Figure 3 shows the evolution of eyesight clarity and visual comfort symptoms before and after treatment with vision therapy.

Table 4. Pre-Therapy and Post-Therapy BIVSS Checklist

Symptom checklist	Pre-therapy	Post-therapy
EYESIGHT CLARITY		
Distance vision blurred and not clear – even with lenses	1	0
Near vision blurred and not clear – even with lenses	3	0
Clarity of vision changes or fluctuates during the day	3	1
Poor night vision / can't see well to drive at night	0	0
VISUAL COMFORT		
Eye discomfort / sore eyes / eyestrain	3	0
Headaches or dizziness after using eyes	3	1
Eye fatigue / very tired after using eyes all day	3	0
Feel "pulling" around the eyes	2	0
DOUBLING		
Double vision – especially when tired	1	0
Have to close or cover one eye to see clearly	0	0
Print moves in and out of focus when reading	0	0
LIGHT SENSITIVITY		
Normal indoor lighting is uncomfortable – too much glare	1	0
Outdoor light too bright – have to use sunglasses	0	0
Indoors fluorescent lighting is bothersome or annoying	0	0
DRY EYES		
Eyes feel "dry" and sting	0	0
"Stare" into space without blinking	0	0
Have to rub the eyes a lot	0	0
DEPTH PERCEPTION		
Clumsiness / misjudge where objects really are	0	0
Lack of confidence walking / missing steps / stumbling	2	0
Poor handwriting (spacing, size, legibility)	0	0
PERIPHERAL VISION		
Side vision distorted / objects move or change position	4	4
What looks straight ahead isn't always straight ahead	0	0
Avoid crowds / can't tolerate "visually-busy" places	0	0
READING		
Short attention span / easily distracted when reading	2	2
Difficulty / slowness with reading and writing	1	1
Poor reading comprehension / can't remember what was read	0	0
Confusion of words / skip words during reading	0	0
Lose place / have to use finger not to lose place when reading	0	0

Note: Score 0 = never, 1 = seldom, 2 = occasionally, 3 = frequently, 4 = always.14

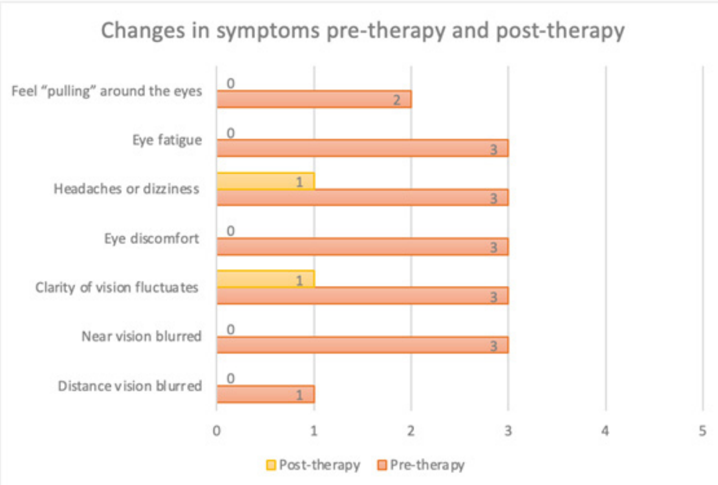

Figure 3. Evolution of eyesight clarity and visual comfort symptoms before and after treatment with vision therapy

Optometric Evaluation

The changes in clinical measures after treatment are listed in Table 5. The speed of the King-Devick test decreased to 46.8 sec, which corresponded to the 42nd percentile. There was improvement of stereopsis post-therapy as well, from 80 seconds of arc to 40 seconds of arc. After treatment, fusional vergence ranges met the expected values. Figure 4 (distance) and Figure 5 (near) show the evolution in fusional vergence.

Discussion

Overview

The results of the post-treatment optometric examination and the post-treatment BIVSS questionnaire in this case report indicate that office-based vision therapy is effective in reducing visual symptoms and improving oculomotor dysfunctions after mild traumatic brain injury. Clinical measures of fusional vergence, stereopsis, and saccadic function improved after a series of 8 in-office vision therapy sessions and daily home exercises. After treatment, the patient's visual complaints were reduced, resulting in an improvement of his quality of life.

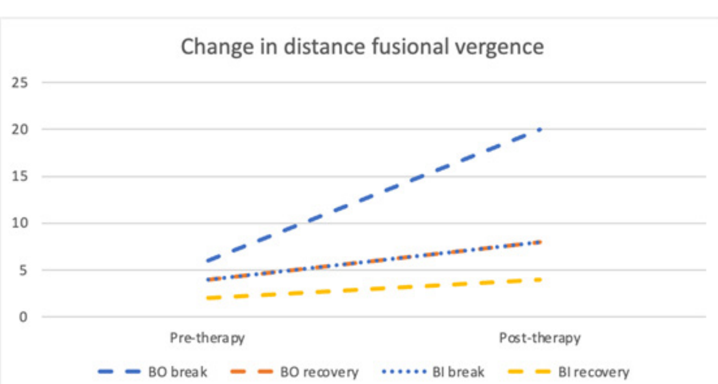

Figure 4. Pre-therapy and post-therapy distance fusional vergence

Table 5. Pre- and Post-Therapy Optometric Test Results

Clinical measure	Initial exam	Post-therapy
Static distance visual acuity	OD: 20/12.5	OD: 20/16
	OS: 20/16	OS: 20/16
	OU: 20/12.5	OU: 20/12.5
Dynamic distance visual acuity	OU: 20/16	OU: 20/16
Near visual acuity	OU: 20/20	OU: 20/20
Cover test distance	Orthophoria	Orthophoria
Cover test near	Orthophoria	Orthophoria
Retinoscopy	OD: +0.75	OD: +1.00
	OS: +1.00	OS: +1.00
Subjective refraction	OD: +1.00-0.25x075	OD: +1.00-0.50x075
	OS: +1.50-0.75x105	OS: +1.25-0.75x105
Distance phoria	0.5 XP	1 XP
Near phoria	2 XP	6 XP
Positive fusional vergence distance	x/6/4	18/20/8
Negative fusional vergence distance	4/2	8/4
Positive fusional vergence near	x/6/4	x/34/18
Negative fusional vergence near	x/5/4	14/24/18
Wirt circles Stereo Optical StereoTest	6 (80 arc seconds)	9 (40 arc seconds)
Gross saccades (Maples)	Good	Good
Gross pursuits (Maples)	Good	Good
NPC	3 cm	3 cm
Worth 4-dot distance	4	4
Worth 4-dot near	4	4
King-Devick	58.2 sec / 5th percentile	46.8 sec / 42nd percentile

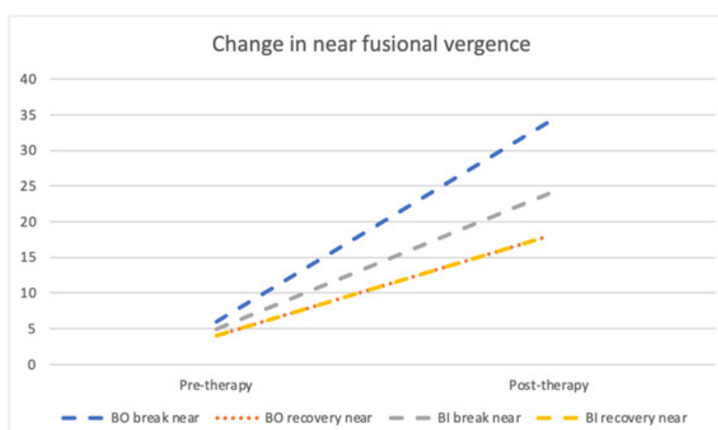

Figure 5. Pre-therapy and post-therapy near fusional vergence

Optometric Examination in mTBI

According to McLeod and Hale,[11] oculomotor function assessment is an important part of the initial clinical examination of a patient with a concussion. It can rule out cranial nerve pathology and more severe brain injury. Measurement of saccades, smooth pursuits, and vergence are useful in detecting changes associated with mild TBI.[18] This may be because brain consequences tend to be diffuse due to the coup-contrecoup nature of the injury in TBI. Diffuse axonal injury can result in shearing of the axons for cranial nerves III, IV, and VI. This leads to oculomotor responses that are less accurate and poorly sustained.[7]

The assessment of versional eye movements should include the fixation, saccade, pursuit, vestibular, and optokinetic systems. Assessment of vergence eye movements should include accommodative vergence and AC/A ratio, fusional vergence ranges at distance and near, near point of convergence, and vergence flexibility at near.[19] Assessment of accommodation should include the amplitude of accommodation, relative accommodation, lag of accommodation, and accommodative flexibility at near.[19]

The oculomotor examination in this patient included measurement of fixation and saccades, smooth pursuits, VOR, fusional vergence ranges at distance and near, and near point of convergence. Accommodative function was not measured due to the age of the patient. However, despite his age, assessment of accommodative function would have been useful. According to the Hofstetter equation, mean accommodative amplitude (AA) for this patient should be 5.3 D (18.5–0.3x44), and minimum AA should be 4 D (15–0.25x44).[20] If accommodative amplitude had been less than 4 D, this could certainly have contributed to blurred near vision. Perhaps a low AA could also be a result of the brain injury, since accommodative insufficiency is quite common after mild TBI.[5] Vergence flexibility in free space was not evaluated either. Szymanowicz et al.[21] found that prism facility does not exhibit significant fatigue upon repetition, despite the frequent complaint of visual fatigue in the mTBI population.

Effect of Oculomotor Dysfunctions on Quality of Life

The patient treated in this case report was diagnosed with fusional vergence dysfunction and saccadic dysfunction. Saccadic dysfunction is a common type of concussion-related vision disorder, whereas fusional vergence dysfunction is less diagnosed in this population.[22]

Saccades are crucial in reading and sports and contribute to the organization of everyday activities, such as walking, driving, or cooking. A saccadic dysfunction has a potential negative impact on these activities.[23]

In fusional vergence dysfunction, the fusional vergence system is unable to respond rapidly and accurately to changing vergence demands over time. Symptoms associated with vergence anomalies are blurred vision at near, eye strain, diplopia, eye fatigue, watery eyes, and headaches.[24] The symptoms the patient reported on the BIVSS in the areas of eyesight clarity and visual comfort could be attributed to fusional vergence dysfunction.

Reading involves synchrony within and between accommodation, vergence, and versional movements. Since the oculomotor system is commonly affected after a TBI, difficulty with reading is a symptom in many TBI patients. A combination of intermittent blur or diplopia due to accommodative or vergence dysfunction, skipping words and lines, and loss of place due to a saccadic dysfunction can affect reading.[25] The difficulties the patient reported on the BIVSS in the area of reading might be caused by both saccadic dysfunction and fusional vergence dysfunction.

Pre-therapy optometric evaluation revealed reduced stereopsis. According to Birnbaum,[13] failure to pass the entire Stereo Optical Stereo Test is a sign of binocular vision dysfunction, since stereoacuity poorer than 40 seconds of arc is considered abnormal. Hellerstein et al.[26] found that stereo acuity was significantly reduced in a TBI population. On the pre-therapy BIVSS, the patient reported occasional "lack of confidence walking/missing steps/stumbling." Post-therapy stereopsis was improved. The patient did not report any difficulties in depth perception after treatment.

The patient in this case report also had a visual field defect, caused by retinal hemorrhage. Visual field deficits have been found in 35% of mTBI patients.[27] Specific visual scanning techniques can be used to improve object detection, and increased head movement may be encouraged in the case of visual field defects. However, daily life of the patient in this study was not affected by the visual field loss; thus, scanning techniques for visual field loss were not included in the treatment with vision therapy.

Vision Therapy as a Treatment of Oculomotor Dysfunctions in mTBI

According to Barnett & Singman,[9] oculomotor vision rehabilitation (OVR) can treat some oculomotor deficits that commonly occur in mild TBI. OVR makes use of motor training combined with attention training. The goal is to optimize vergence, accommodation, fixation, and saccades to overcome visual deficits.

The patient in this case report showed increased vergence ranges, improved stereopsis, and better saccadic function after treatment. He reported a reduction in visual complaints post-therapy. These results are consistent with previous research. Gallaway et al.[22] indicate an excellent success rate for patients who were treated with vision therapy for concussion-related vision disorders. In three case reports by Möller et al.,[28] all mTBI patients agreed that vision therapy helped their overall recovery. Johansson et al.[29] concluded in their study that vision therapy was an efficient treatment, resulting in improved visual functions and reduced symptoms after acquired brain injury. In a study by Conrad et al.,[30] the percentage of brain injury patients who were classified as successful after home-based computer vergence therapy was 77% for positive fusional vergence, 77% for negative fusional vergence, and 92% for vergence facility. Previous research by Möller et al.[28] concluded that face-to-face sessions are associated with even more pronounced improvement.

The treatment in this patient took place about 2 years 5 months after the brain injury. Even though the time since the trauma was more than two years, this shows that it was still possible to improve visual function. This is even better than the results of a case series by Möller et al.,[28] where visual improvement was achieved more than one year after trauma.

Limitations and Strengths

An absolute strength of this case study is the perseverance of the patient. He was very compliant. The patient was punctual at every appointment, was intrinsically motivated to heal, and performed his home exercises on a regular basis and with great self-discipline. Another strength is the use of validated and reliable equipment for testing, and the fact that only one examiner performed the eye examinations.

A possible limitation in this case report is the use of Risley rotary prisms to measure fusional vergence. Goss and Becker[31] studied the differences between near fusional vergence ranges determined with phoropter rotary prisms and those determined with prism bars. They found the ranges with the prism bar to be greater than the ones with the rotary prisms. Therefore, fusional vergence ranges measured by prism bars cannot be used interchangeably with those measured by rotary prisms. In this case, there was only one examiner, who used the same technique for all measurements. This ensures reliable clinical measurement of vergence ranges.

A limitation in this case report is the patient's refractive error. Optometric examination revealed a hyperopic refractive error. The patient refused to wear any optical correction. However, in TBI, latent hyperopia can become manifest because of an abnormally functioning parasympathetic system. The ability to compensate for uncorrected hyperopia with accommodation can be compromised. Many mTBI patients exhibit high sensitivity to small, uncorrected refractive errors.[27]

Correcting the patient's hyperopia could have had a positive influence on reading as well. Previous research is divided about the benefits of plus lenses on reading performance. Wildsoet and Foo[32] assessed reading performance in children with low hyperopia through both low plus lenses and plano. They found no significant improvement in reading performance when wearing the plus lenses. Iyer and Harris[33] found no statistically significant difference between plano and low plus lenses on reading speed, but they did find a significant increase in reading comprehension with plus lenses. However, too much plus seemed to be detrimental to reading efficiency. A study by O'Leary et al.[34] showed that the reading speed of non-presbyopic hyperopes did not improve significantly when hyperopia was corrected with plus lenses. However, in the presbyopia group (age 35 – 60 years), there was a significant improvement in reading performance with reading additions of +1.00 DS and greater. The patient in this case report was 44 years old and circa 1.00 D hyperopic. Based on previous research, it can be assumed that correcting the hyperopia would have been beneficial for his reading efficiency.

Dwyer and Wick[35] examined the influence of refractive correction upon vergence and accommodation disorders. In their study, 52.4% of the patients were diagnosed with fusional vergence dysfunction. The binocular and refractive status were remeasured after at least one month of wearing the spectacles full time. A total of 66% of the patients with fusional vergence dysfunction showed recovery of normal vergence findings. Moreover, patients with hyperopic astigmatism appeared to benefit the most from wearing the correction: 79% showed improvement. Based on this research, it can be assumed that the patient in this case report, diagnosed with fusional vergence dysfunction, would have benefited from wearing a correction with plus lenses.

Despite the improvement in the results of the King-Devick test, the patient did not report an increase in reading performance. This is not consistent with previous research and case series. Thiagarajan et al.[25] found a significant 25% improvement in reading rate after oculomotor training for 6 weeks. In a case series by Kapoor et al.,[36] a TBI patient showed improvement in reading eye movements and reading ability after 8 weeks of vision therapy. A possible explanation is that the assumption that reading performance did not improve was based on the patient's answers to the BIVSS questionnaire. This is very subjective. Using a standardized functional reading test to detect benefits of the oculomotor training in the reading area should have been considered. Another possible explanation is that efficient reading requires the precise coordination of the lower-level, oculomotor and the higher-level, non-oculomotor processes. This means that not only version, accommodation, and vergence are involved, but also attention, linguistic, memory, and cognitive processes.[25] Deficits in the higher-level processes were neither evaluated nor treated in this patient.

Pre-therapy, the patient reported dizziness after using his eyes. Vestibular impairments are common after concussion.[11] Dizziness may represent an underlying impairment of the oculomotor and/or the vestibular systems.[37] Not only cranial nerve and oculomotor assessments are indicated; balance assessment is also an important aspect of concussion management.[11] Mucha et al.[37] developed the Vestibular/Ocular Motor Screening (VOMS) assessment, a screening tool to assess vestibular and oculomotor impairments in concussion patients. The VOMS assessment includes smooth pursuit, horizontal and vertical saccades, near point of convergence, VOR, and visual motion sensitivity (VMS). They found the assessment of VOR, VMS, and NPC to often provoke vestibular symptoms in concussion patients. In this patient, assessment of visual motion sensitivity would have been useful. However, the aim was to find out whether oculomotor training benefits visual symptoms after concussion. If the vestibular system had also been assessed, the essence of this case report would have been lost.

Despite these limitations, this case provides insight into the effectiveness of vision therapy for TBI-related vision disorders, especially since this patient did not suffer from the most common oculomotor dysfunction after mild traumatic brain injury, convergence insufficiency.

Screening for oculomotor dysfunctions in mTBI patients and treatment of oculomotor dysfunctions with vision therapy is important to improve the quality of life of people suffering from mild traumatic brain injury.

Conclusion

Oculomotor dysfunctions are common after mild traumatic brain injury. Evaluation of patients with mTBI should include testing of vergence and eye movement function. This case report shows that office-based oculomotor therapy with home reinforcement is effective in improving oculomotor function and reducing visual symptoms in an mTBI patient with saccadic dysfunction and fusional vergence dysfunction. The reduction in visual complaints had a positive effect on the patient's daily life.

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