Article ▸ # Management of Convergence Insufficiency and Oculomotor Dysfunction: A Neuro-Optometric Perspective

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ABSTRACT

Background: Sensory problems are common after traumatic brain injury, which can lead to the disruption of the visual process, causing eye problems such as difficulty with accommodative function, binocular fusion, and fixation ability. MRI findings are usually normal in mild traumatic brain injury (mTBI). However, these patients present with varying visual comorbidities. The injuries sustained are most often diffuse and are caused by shearing and stretching of the brain fibers, as well as the neurotoxic cascade induced by the injury. Management of such cases requires an interdisciplinary approach where optometrists play an important role in delivering primary eye care. This case report emphasizes the role of an optometrist in the diagnosis and management of mTBI-related vision disorders.

Case Report: Mr. A, a 25-year-old gentleman, presented to the Neuro-Optometry Clinic (NOC) with a chief complaint of difficulty tracking words and of letters moving during reading. These symptoms began following a head injury due to a fall 6 months prior. He also complained of dizziness while moving his eyes and difficulty remembering the text he read. He was first examined in the Neuro-Ophthalmology clinic and was referred to the NOC for further evaluation. At NOC, he was diagnosed with convergence insufficiency, oculomotor dysfunction, and mild visual motion sensitivity. He underwent vision therapy for 10 sessions to train accommodation, vergence, and eye movements. His symptoms decreased, and the binocular vision parameters and reading speed improved from baseline.

Conclusion: Neuro-Optometric Vision Therapy (NOVT) is an important treatment option to eliminate the visual symptoms and to improve the quality of life in patients with mTBI.

Keywords: convergence insufficiency, mild traumatic brain injury, oculomotor dysfunction, ReadAlyzer, vision therapy

Introduction

Head injuries are a growing concern in every part of the world, and optometrists play an important role in dealing with the visual comorbidities present in patients with head injury. The four-tiered approach proposed by Ciuffreda[1] explains the visual, oculomotor, non-oculomotor, and non-visual issues present in mild traumatic brain injury (mTBI). In the first tier, the focus is on ocular health issues, wherein comprehensive eye examination and basic binocular vision assessment is emphasized. In tier two, detailed vergence and accommodation testing, along with specific oculomotor testing, are emphasized. Here, monocular and binocular eye movement parameters such as versions, vergences, saccades, pursuits, and vestibular and optokinetic systems are tested, and appropriate remediation is advised. The third tier focuses on non-oculomotor issues such as abnormal egocentric localization, photosensitivity, dizziness, vestibular dysfunction, visual perceptual deficits, motion sensitivity, and visual motion-related issues. Appropriate assessment and optometric vision therapy to remediate these deficits are emphasized in this approach. The fourth tier is based on non-ocular issues such as depression, cognitive impairment, behavioural issues, postural problems, and neurological illness that can have an impact on the previous three tiers. Referral for appropriate professional consultation and counselling are to be made based on the findings in the fourth tier.

Sixty percent of traumatic brain injuries in India are attributed to road traffic accidents (RTA).[2] In the US, according to The Centers for Disease Control and Prevention (CDC), 1.7 million have experienced TBI, TBI being the leading cause of death and disability.[3] In India, 0.12 million people die due to RTA, and 1.27 million sustain serious injuries every year. Concussion-related brain injuries are the most common after RTA.[4]

According to the CDC, an estimated 1.6 million to 3.8 million concussions occur in the United States each year, and of those, 65% are estimated to occur in the pediatric and adolescent populations. The common physical symptoms associated with concussion and mTBI are headache, nausea, vomiting, dizziness, fatigue, blurred vision, sleep disturbance, sensitivity to light/noise, balance problems, and transient neurological abnormalities. Other cognitive symptoms include poor attention, concentration, memory, speed of processing, and executive function. Behavioral symptoms include depression, anxiety, agitation, irritability,

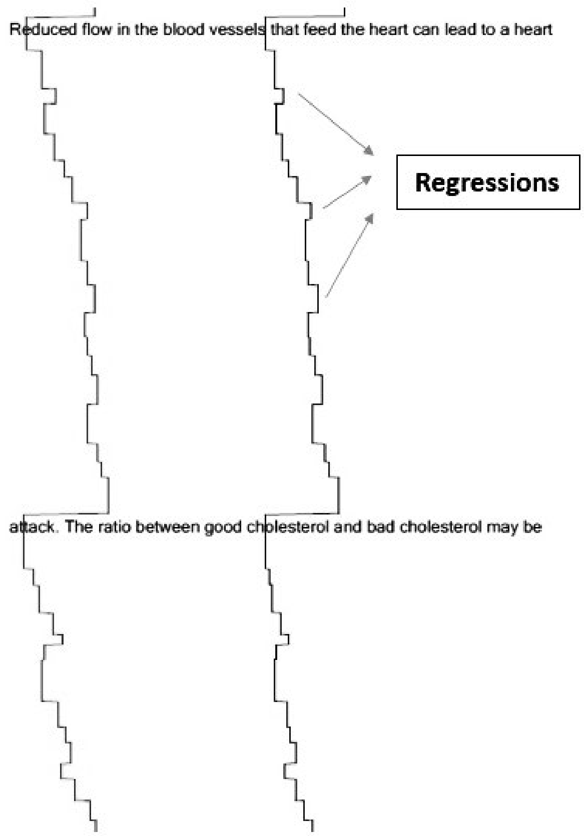

Figure 1. *Reading graph for a grade-10-level text at the baseline visit measured using the ReadAlyzer. Graph shows increased number of fixations and regressions (arrow marks).*

and impulsivity.[5] Hence, concussion-related TBI is becoming a public health issue across all ages.[3]

Vision problems such as convergence insufficiency (CI), accommodative insufficiency (AI), and saccadic dysfunction are common after traumatic brain injury.[6,7] In combat-injured service members, vision dysfunctions including CI, AI, oculomotor dysfunction (OMD), and fixation instabilities were common among individuals with mTBI, and vision impairment was common in severe TBI;[8] similar findings have been reported in patients with poly-trauma injury.[9,10] Abnormal vergence adaptation has been reported to be a causative factor in the large exophoria seen at near in mTBI.[7] Individuals with mTBI present with increased saccadic latencies, slowed saccades, impaired predictive tracking, and saccadic dysmetria.[11] These oculomotor anomalies hamper the sensory and motor aspects of vision and reduce the attentional and spatial allocation aspects, thereby affecting text processing and comprehension.[12,13]

Treatment

While the efficacy of vision therapy for the remediation of vergence, accommodative, and oculomotor dysfunctions in the general population is well established, vision therapy remains challenging for the TBI population due to added issues such as excessive fatigue, memory loss, depression, general health issues, and visual symptoms such as photosensitivity and glare.[14,15] Nevertheless, targeted, specific, and structured vision therapy procedures have been proven to be effective in improving vergence, binocular vision parameters, and symptoms in patients with brain injuries.[16,17]

Neuro-Optometric Vision Therapy (NOVT) includes the design and prescription of therapeutic and/or compensatory lenses or prisms, vision therapy, other necessary visual modalities, and strategies to enhance and to rehabilitate disrupted visual function. This case report deals with mTBI-related vision disorders, including the clinical presentation and role of objective eye movement recording and vision therapy.

Case Report

History

Mr. A, a 25-year-old gentleman, presented to the Neuro-Ophthalmology Clinic with a chief complaint of difficulty in tracking words and the perception that letters were jumping on the page during continuous reading for the past 6 months. He also complained of dizziness while moving his eyes. He had no other visual complaints for distance or near. He had a history of a fall from a height of 12 feet that occurred 6 months prior, causing an injury to his head and lower back region. He reported loss of consciousness for less than 10 minutes. Visual symptoms were noticed following the trauma. There was no history of significant systemic illness. He was taking anti-depressant medications. MRI scan showed no significant abnormality, and no diagnosis of concussion was documented.

Clinical Findings

Visual acuity was 20/15 in both the eyes for distance and N6 @ 30-40 cm for near. There was no significant refractive error. Retinoscopy revealed +0.25 DS in both the eyes, and the findings were confirmed through cycloplegic refraction. Subjective acceptance was plano in both the eyes, and the duochrome was balanced. The cover test revealed orthophoria for distance and near. Ocular motility tested with the "Broad-H" method showed full, free, and painless movements in both eyes. Pupillary examination showed normally reacting pupils to light and accommodation in both eyes. Signs of relative afferent pupillary defect were absent. Color vision tested with Ishihara Pseudo-isochromatic plates was normal, with a score of 21/21 in both eyes. Anterior segment evaluation showed normal findings. Intraocular pressure (IOP) with Goldmann Applanation Tonometry revealed 13 mm Hg in both eyes. Dilated fundus examination showed normal retinas and healthy optic discs. Humphrey visual field testing using the SITA FAST program with the 30-2 strategy revealed normal fields for the right and left eyes.

Visual Efficiency Examination

Mr. A was a student preparing for the Civil Service examinations and was unable to read for more than 2 hours/day. He had complaints of headache, eyestrain associated with near tasks such as reading, and dizziness while moving his eyes.

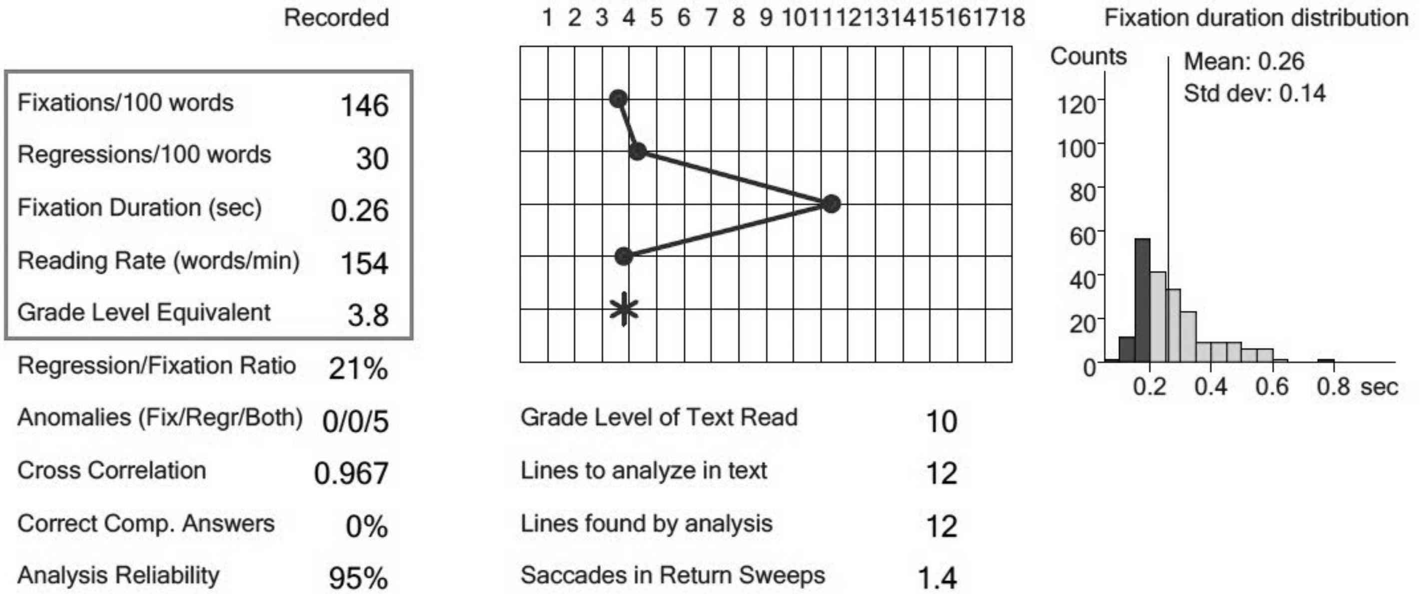

Figure 2. *Reading profile at the baseline visit. The asterisk represents the grade level equivalent (GLE) of the patient with reading performance.*

Table 1. Visual Efficiency Examination Results

DIAGNOSTIC DATA	RESULTS
Stereopsis (arc seconds)	Wirt – 30, Animals – 100, RDS – 250
Worth Four Dot Test	Distance and Near: Fusion
Saccades (NSUCO)	5/5/5 (c/o Mild dizziness)
Pursuits (NSUCO)	5/5/5
Cover Test (all 9 gazes)	Distance and Near: Orthophoria
NPC (Break/Recovery) **1. Accommodative target** **2. Pen light and R/G Filter**	1. Subjective: 6/8 cm; Objective: 6 cm 2. Subjective: 22/34 cm Comments: Receded NPC under dissociated condition
NPA cm (Amplitude of Accommodation – D)	OD: 8 cm (12.5 D), OS: 7 cm (14.3 D), OU: 8 cm (12.5 D) Comments: Normal
MEM Retinoscopy	OD: +0.50 DS, OS: +0.50 DS Comments: OU Normal lag of accommodation
Fusional Vergence Amplitudes (Step Vergence)	See below *Comments: NFV – Normal, Reduced PFV for distance*
Vergence Facility (12 BO/3 BI flippers)	10 cpm Comments: Difficulty fusing BO
Accommodative Facility (+/-2.00 DS flippers)	OD: 5.5 cpm OS: 3.5 cpm OU: 11.5 cpm Comments: Difficulty with plus lenses
Developmental Eye Movement (DEM) Test	Test A: 16.1 sec, Test B: 17 sec, **A+B= 33.1 (47th percentile)** Test C: **30.9 sec (73rd percentile)** **Errors – 0 for H & V tests** H/V ratio: 0.9 (>91st percentile) Comments: Normal
Vestibulo-Ocular Reflex (Horizontal head impulse test)	Normal (c/o Mild dizziness)
Cranial Nerve Evaluation (I/V/VII/VIII/IX/X/XI/XII)	WNL
Confrontation and Amsler Testing	OD: WNL, OS: WNL
Visual Midline Shift Test	No shift noted
Visual Neglect (Line Bisection Test)	Absent

Fusional Vergence Amplitudes (Step Vergence):

		Blur	Break	Recovery
NFV	D	X	10	8
	N	X	14	12
PFV	D	X	12	10
	N	X	30	25

Table 2. Details of Neuro-Optometric Vision Therapy Provided for this Patient

Sitting No.	Vision Therapy
1	Brock string, RDS in Computer orthoptics, Saccades and Pursuits training, Barrel card, Accommodative flippers +/-1.00 DS with N8
2	Brock string, MCV Stereo, Saccades, Pursuits, Accommodative flippers +/-1.50 DS with N10
3	Tranaglyphs, MCV Stereo, Saccades, Pursuits, Accommodative flippers +/-1.50 DS with N8
4	Computer orthoptics – MCV Flat Fusion, Brock string, Accommodative flippers +/-1.75 DS with N10 target
5	Vectograms, Computer orthoptics – Jump RDS, Saccades and Pursuits training, Accommodative flippers +/-1.75 DS with N8
6	Tranaglyphs with R/G filter, Computer orthoptics – Jump Stereo, Saccades and Pursuits training, Accommodative flippers +/2.00 DS with N10
7	Computer orthoptics – Jump vergence in Flat fusion, Aperture rule, Saccades and Pursuits training, Accommodative flippers +/2.00 DS with N8
8	Computer Orthoptics – Jump vergence in Flat fusion, Aperture rule, Eccentric Circle, Life saver card, Brock string, Saccades and Pursuits training, Accommodative rock No 2 with 4 targets
9	Computer Orthoptics – Jump vergence in Simultaneous perception, Aperture rule, Saccades and Pursuits training, Accommodative flippers +/2.00 DS with N8
10	Bernell-o-scope for vergence training, Eccentric circles at all gazes, Hart chart (for saccadic and accommodative facility training), Life saver card at all gazes, Saccades and Pursuits training

The binocular vision assessment findings are provided in Table 1. His near point of convergence was receded with the penlight and red/green filter. Although positive fusional vergence ranges were normal at near, he reported difficulty with base-out prisms and took a longer time to fuse during vergence facility testing. In addition, monocular accommodative facility was reduced, with more difficulty noted with plus lenses.

The eye movements were objectively measured using the ReadAlyzer eye movement recording system.[18] The reading graph shows the pattern of eye movements made by the patient while reading (Figure 1). The reading profile parameters were as follows: fixations/100 words: 146; regressions/100 words: 30; reading rate: 154 words/min; and grade level equivalent: 3.8 (Figure 2; highlighted with a blue square). Based on Taylor's normative data, the patient's performance is below expected.[11] The vestibulo-ocular reflex was tested using the horizontal head impulse test,[19] in which the patient is asked to fixate a distant static target, and the head is rotated horizontally in a forceful manner. The stability of fixation is observed after the head is fixed. When the head is rotated, the patient is asked to report any subjective symptoms of dizziness and difficulty in fixating and following the target.

Diagnoses

1. Convergence insufficiency-based on the receded near point of convergence and borderline vergence facility response
2. Secondary accommodative excess – due to difficulty with plus lenses during accommodative facility testing
3. Saccadic dysfunction – Reduced reading rate with increased number of fixations and regressions when compared to the normative values for his grade level
4. Visual Motion Sensitivity (VMS) – due to dizziness with eye movements and head rotation

Vision Therapy Goals

In the sequential management approach, prescription of refractive correction is the first approach, followed by a therapeutic approach of prescribing added plus lenses for the low AC/A ratio. In this case, the patient was an emmetrope with a low AC/A ratio, therefore lenses would not be beneficial, and prisms were not recommended due to insignificant phoria and absence of diplopia. VMS can be treated with conventional methods such as binasal occlusion[20] or yoked prisms. As the patient was uncomfortable with binasal occlusion, vision therapy was chosen.

Vision therapy was advised to improve the near point of convergence, accommodation, and eye movements. The estimated number of therapy sessions was expected to be between 20 and 25 according to Scheiman and Wick.[21] The goals for training the oculomotor system were based on the guidelines proposed by Scheiman and Wick.[21]

Vision Therapy

The patient attended in-office vision therapy once per day (each session for 60 minutes) for 10 consecutive days. Vision therapy details are provided in Table 2. The patient completed all 10 sessions of in-office vision therapy.

Third-degree fusion was trained first using random dot stereograms, followed by stereopsis, and then using flat fusion and simultaneous perception. Cues to perform the therapy, such as SILO and luster, were advised and achieved by the patient. Both monocular and binocular training were given for accommodative facility using flippers. The patient performed the facility exercises on his own by calling out the words from the word rock card in a given minute and noting down the number of words read while alternately flipping the lenses. Computer orthoptics was used to train saccades and pursuit eye movements. Hart chart was also used to train saccadic eye movements and fixations. Once all the endpoints were attained, in-office vision therapy was completed.

Reassessment

The vergence amplitudes and accommodative facility parameters improved from the baseline measurements. Improvements were noted in the reading eye movement parameters post-vision therapy, as shown in Figures 3 and 4. The results pre- and post-vision therapy are listed in Table 3 Visual symptoms were reported to be decreased (Pre CISS: 23; Post CISS: 13). He was able to read for a longer duration, more than 4 hours/day. Home vision therapy with eccentric circles, Life Saver card, and Hart chart was advised as maintenance therapy to sustain the improvement. Hart chart was prescribed

Table 3. Results Before and After In-office Vision Therapy

DIAGNOSTIC DATA	RESULTS (Before VT)	RESULTS (After VT)
Saccades (NSUCO)	5/5/5 (c/o Mild dizziness)	5/5/5 (Dizziness reduced)
Pursuits (NSUCO)	5/5/5	5/5/5
Cover Test (all 9 gazes)	Distance and Near: Orthophoria	Distance and Near: Orthophoria
NPC (Break/Recovery) 1. Accommodative target 2. Pen light and R/G Filter	1. Subjective: 6/8 cm; Objective: 6 cm 2. Subjective: 22/34 cm Comments: Receded NPC under dissociated condition	1. Subjective: 5/7 cm; Objective: 5 cm 2. Subjective: 16/20 cm Comments: Improved NPC under dissociated condition
NPA cm (Amplitude of Accommodation – D)	OD: 8 cm (12.5 D), OS: 7 cm (14.3 D), OU: 8 cm (12.5 D) Comments: Normal	OD: 8 cm (12.5 D), OS: 7 cm (14.3 D), OU: 8 cm (12.5 D) Comments: Normal

Fusional Vergence Amplitudes (Step Vergence)

		Before VT: Blur	Break	Recovery	After VT: Blur	Break	Recovery
NFV	D	X	10	8	X	12	10
	N	X	14	12	X	14	12
PFV	D	X	12	10	X	30	25
	N	X	30	25	X	35	30
		Comments: NFV – Normal, Reduced PFV for distance			*Comments: NFV and PFV – Normal*		

DIAGNOSTIC DATA	RESULTS (Before VT)	RESULTS (After VT)
Vergence Facility (12 BO/3 BI flippers)	10 cpm Comments: Difficulty fusing BO	11 cpm Comments: Difficulty fusing BO
Accommodative Facility (+/-2.00 DS flippers)	OD: 5.5 cpm OS: 3.5 cpm OU: 11.5 cpm Comments: Difficulty with plus lenses	OD: 18 cpm OS: 17 cpm OU: 13.5 cpm Comments: Equally clears plus and minus lenses

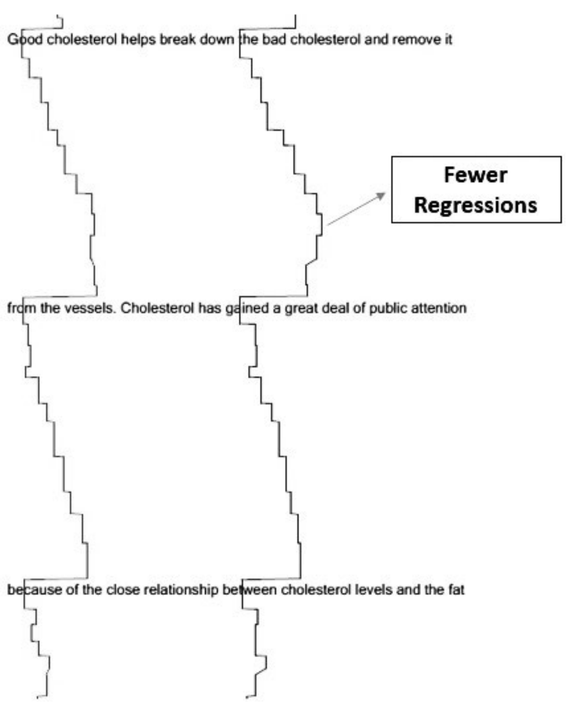

Figure 3. *Reading graph for a grade-10-level text after 10 sessions of vision therapy. This graph shows that his number of fixations and regressions is less and his reading has improved from the baseline visit after vision therapy.*

for accommodative therapy and also to train saccadic eye movements and fixations. He was advised to return for a follow-up in 3 months.

Discussion

Visual problems are common sequelae following mTBI, which causes a constellation of symptoms including vision and oculomotor-related problems.[8] Suchoff et al. reported that the presence of exodeviations, oculomotor dysfunctions, and vertical deviations was higher in the TBI sample compared to an age-matched reference sample.[13] In mTBI, there is diffuse axonal injury that reduces the firing rate of the synaptic impulse conductions, causing a range of visual dysfunctions: binocular vision anomalies, accommodative dysfunctions, and eye movement dysfunctions. The primary anomaly in mTBI is identified to be the pulse mechanism of the vergence response, resulting in reduced dynamics of the convergence and divergence responses.[7]

Patients with a history of TBI may also experience other additional symptoms following the trauma, such as difficulties with balance, spatial orientation, hand-eye coordination, and cognitive inattention.[22] Afferent visual pathway defects can cause color vision defects and visual field deficits. Light sensitivity is reported to be common in blast-related injuries, and saccadic dysfunction is more common among non-blast-related injuries. The mechanisms of this discrepancy between blast-induced and non-blast-related injuries, and the role of head injury in causing visual symptoms, still remain unclear.[23]

One of the most important visual functions in every individual's daily living is reading. When reading, an individual with mTBI may exhibit shorter saccade lengths, increased number of fixations and regressions, and reduced reading rate.[14,22] Assessment of reading is emphasized in individuals with TBI to test the functional integrity of the oculomotor system.[24] The problems with saccadic eye movements affect the sensory and motor aspects of the individual. This has an effect on text processing, comprehension, and attention. Due to this relationship, people with mTBI may not be able to read with comfort

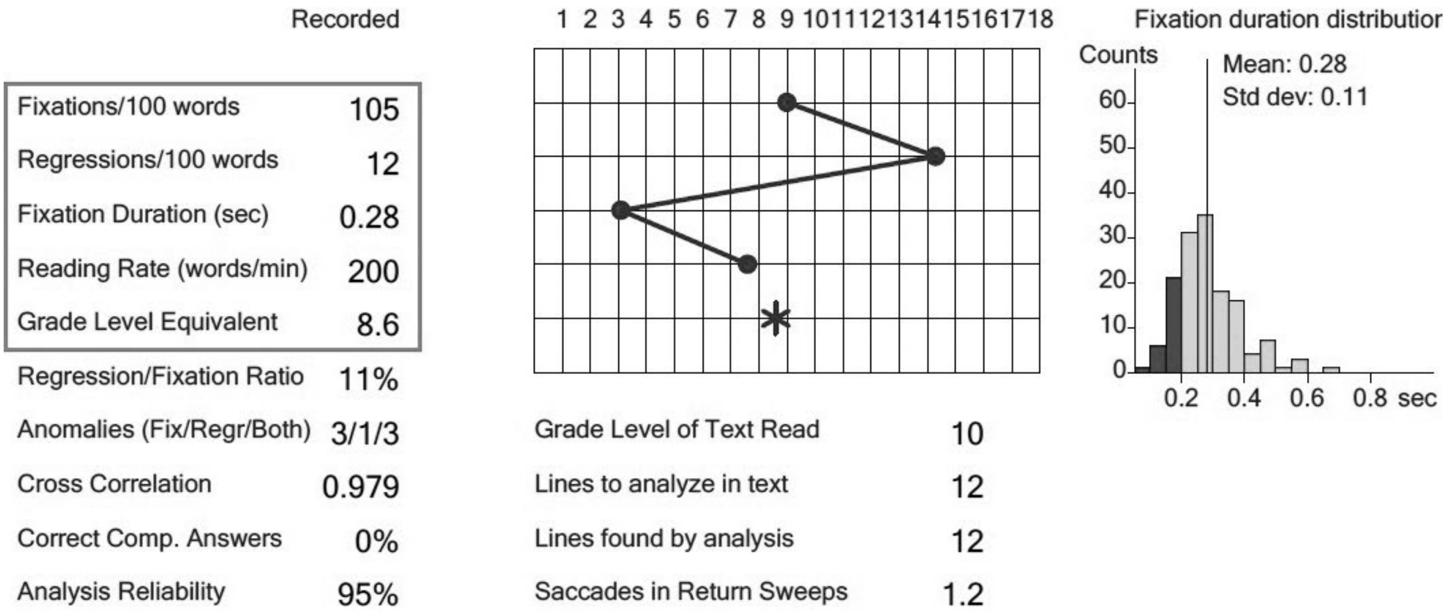

Figure 4. *Reading profile graph after 10 sessions of vision therapy. Reading rate has improved from 154 to 200 words/minute and GLE from 3.8 to 8.5 from the baseline.*

for a prolonged time, and their ability to perform routine activities of daily living may be compromised in severe cases.

A sudden stress to the brain reduces the firing rate in synaptic transmission, resulting in symptoms as noted in this case of Mr. A. Of the twelve pairs of cranial nerves, six are involved with vision.[22] When the lower-level aspects of vision are compromised, higher-level aspects such as comprehension, persistent attention, and visual memory may be impacted.

A structured vision therapy program is effective in improving the visual efficiency and visual symptoms in TBI. In a cross-over experimental study design, 9 weeks of oculomotor training (OMT) significantly improved the vergence parameters and visual attention in a sample of patients with mTBI. Oculomotor learning has been suggested as the mechanism for improved visual function in this sample.[25] In the same study sample, dynamic (objective) and static (subjective) measures of accommodation also showed significant improvements after 9 weeks of OMT.[26] In another study, oculomotor rehabilitation also improved VEP latency and decreased the variability of responses in a small sample of mTBI; this was attributed to changes in the early visuo-cortical pathways.[27] As reading requires a sustained level of accommodation and vergence, training these aspects is essential. In this case, vision therapy helped the patient to overcome reading and comprehension issues. VMS was also treated simultaneously with NOVT to train and to achieve a better prognosis with sustainability.

Premature return-to-play in athletes or work following concussion can also prolong the recovery and can cause adverse effects.[28,29] Hence, sufficient recovery time should be reinforced before return to work is recommended. Also, gradual increase in reading hours should be advised to avoid unnecessary load on the accommodative and cognitive systems.

Conclusion

Thirty percent of the brain pathways are devoted to the processing of vision and vision-related information. Three of the twelve cranial nerves (III, IV, and VI) deal with oculomotor control, and it is not surprising that an individual with traumatic brain injury/brain insult may be afflicted with a wide range of sensory and motor deficits involving the visual system. NOVT is an important treatment option to eliminate the visual problems and to improve the daily living skills of patients with mTBI. Regular follow-up is required to assess sustainability and to identify relapse of symptoms. This case report emphasizes the role of an optometrist in the management of mTBI-related vision disorders.

References

1. Ciuffreda KJ, Ludlam D. Conceptual model of optometric vision care in mild traumatic brain injury. J Behav Optom 2011;82:61-3.
2. Munivenkatappa A, Devi BI, Gregor TI, Bhat DI, et al. Bicycle accident related head injuries in India. Journal of Neurosciences in Rural Practice 2013;4:262-66.
3. Centers for Disease Control and Prevention.org. Home page on the Internet. Atlanta: Injury Prevention & Control: Traumatic Brain Injury, Inc.; Updated on January 7 2013; cited 2015, June Available from: http://bit.ly/19Qbo7P
4. Rashid AF, Fazili RA. Two-year study on road traffic accident cases admitted in skims medical college hospital bemina. JK-Practitioner 2013;18(3-4):15-9.
5. Management of Concussion/mTBI Working Group. VA/DoD Clinical Practice Guideline for Management of Concussion/Mild Traumatic Brain Injury. J Rehab Res Devel 2009;46(6):CP1.
6. Ciuffreda KJ, Kapoor N, Rutner D, Suchoff IB, et al. Occurrence of oculomotor dysfunctions in acquired brain injury: a retrospective analysis. Optometry 2007;78(4):155-61.
7. Thiagarajan P, Ciuffreda KJ, Ludlam DP. Vergence dysfunction in mild traumatic brain injury (mTBI): A review. Ophthalmic Physiol Opt 2011;31(5):456-68.
8. Brahm KD, Wilgenburg HM, et al. Visual impairment and dysfunction in combat-injured service members with traumatic brain injury. Optom Vis Sci 2009;86(7):817-25.

9. Goodrich L, Kirby J, et al. Visual Function in Patients of a Polytrauma Rehabilitation Center: A descriptive Study. J Rehab Res Devel 2007; 44(7):929-36.
10. Stelmack JA, Frith T, et al. Visual function in patients followed at a Veterans Affairs polytrauma network site: an electronic medical record review. Optometry 2009;80(8):419-24.
11. Ciuffreda KJ, Tannen B. Eye Movement Basics for the Clinician: St. Louis, MO: Mosby Yearbook, 1995.
12. Ciuffreda KJ, et al. Oculomotor dysfunctions, their remediation, and reading-related problems in mild traumatic brain injury. J Behav Optom 2007;18(3):72-7.
13. Suchoff IB, Kapoor N, et al. The occurrence of ocular and visual dysfunctions in an acquired brain-injured patient sample. J Am Optom Assoc 1999;70(5):301-8.
14. Ciuffreda KJ, Ludlam D, Thiagarajan P. Oculomotor diagnostic protocol for the mTBI population. Optometry 2011;82(2):61-3.
15. Scheiman M, Gallaway M. Vision therapy to treat binocular vision disorders after acquired brain injury: factors affecting prognosis. In: Visual and Vestibular Consequences of Acquired Brain Injury (Suchoff IB, Ciuffreda KJ, Kapoor N, eds). Santa Ana, CA: Optometric Extension Program, 2001:89-113.
16. Ciuffreda KJ, Rutner D, et al. Vision therapy for oculomotor dysfunctions in acquired brain injury: A retrospective analysis. Optometry 2008;79(1):18-22.
17. Thiagarajan P, Ciuffreda KJ. Accommodative and vergence dysfunctions in mTBI: Treatment effects and systems correlations. Optom Vis Perf 2014;2(6):539-54.
18. Webber A, et al. DEM test, visagraph eye movement recordings, and reading ability in children. Optom Vis Sci 2011;88(2):295-302.
19. David E. Neuro-Vestibular Examination. Accessed on 15 July 2015. Available on: http://bit.ly/2nrSNu0
20. Ciuffreda KJ, Yadav NK, Ludlam DP. Effect of binasal occlusion (BNO) on the visual-evoked potential (VEP) in mild traumatic brain injury (mTBI). Brain Inj 2013;27(1):41-7.
21. Scheiman M, Wick B. Clinical Management of Binocular Vision: Heterophoric, Accommodative and Eye Movement Disorders; 3rd ed. Philadelphia: Lippincott Williams & Wilkins, 2008.
22. Thiagarajan P, et al. Oculomotor Neuro-rehabilitation for reading in mild traumatic brain injury (mTBI): An integrative approach. Neuro-Rehabilitation 2014;34:129-46.
23. Goodrich GL, Flyg HM, et al. Mechanisms of TBI and visual consequences in military and veteran populations. Optom Vis Sci 2013;90(2):105-12.
24. Capó-Aponte JE, Urosevich TG, et al. Visual dysfunctions and symptoms during the subacute stage of blast-induced mild traumatic brain injury. Mil Med 2012;177(7):804-13.
25. Thiagarajan P, Ciuffreda KJ. Effect of oculomotor rehabilitation on vergence responsivity in mild traumatic brain injury. J Rehabil Res Dev 2013;50(9):1223-40.
26. Thiagarajan P, Ciuffreda KJ. Effect of oculomotor rehabilitation on accommodative responsivity in mild traumatic brain injury. J Rehabil Res Dev 2014;51(2):175-91.
27. Yadav NK, Thiagarajan P, Ciuffreda KJ. Effect of oculomotor vision rehabilitation on the visual evoked potential and visual attention in mild traumatic brain injury. Brain Inj 2014;28(7):922-9.
28. Master CL, Gioia GA, et al. Importance of 'return-to-learn' in pediatric and adolescent concussion. Pediatr Ann 2012;41(9):1-6.
29. Master CL, Grady MF. Office-based management of pediatric and adolescent concussion. Pediatr Ann 2012;41(9):1-6.

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