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Optometric Management of a Post-Concussion Patient: A Case Report

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ABSTRACT

Over the past decade, there has been increased emphasis on the diagnosis and treatment of concussion, especially in the military and in sports. In this case report, the optometric management of a post-concussion, young-adult is described. He was diagnosed with low myopic astigmatism, convergence insufficiency, fusional instability, oculomotor dysfunction, and photosensitivity. Treatment included tinted spectacle correction for full-time wear and conventional oculomotor-based vision therapy. At the cessation of the vision therapy, as well as three years later, he was effectively asymptomatic with normal clinical findings. These results demonstrate the efficacy of a comprehensive optometric approach in concussion, with evidence suggestive of considerable residual visual system plasticity.

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Tannen NM, Tannen B, Ciuffreda KJ. Optometric management of a post-concussion patient: a case report. Vision Dev & Rehab 2016;2(4):237-42.

Keywords: concussion, mild traumatic brain injury, optometry, photosensitivity, therapeutic tint, vision, vision rehabilitation, vision therapy

INTRODUCTION

The diagnosis and treatment of "concussion", a form of mild traumatic brain injury (mTBI), is one of the relatively new frontiers in optometric care.[1] It has been made more visible and relevant due to the increased prevalence of mTBI in our recent military encounters,[2] as well as its increased recognition in contact sports, such as football.[3] It is believed to have two phases:[4] first, the initial biomechanical phase due to the rapid, coup-contrecoup motion of the gelatinous brain within the rigid cranium at the time of injury, thus resulting in shearing, stretching, and twisting of the brain and its delicate fibrous tracts (e.g., diffuse axonal injury); and second, the biochemical/ physiological phase occurring days and weeks later with the release of neurotoxins in a cascade of events, thus resulting in neuronal death and further disruption/distortion of neural signal transmission.

The occurrence of a concussion may produce a constellation of non-visual and visual sequelae.[4,5] The former may include general headaches, dizziness, nausea, sleep difficulties, hyperacusis, and cognitive problems, as well as many others. Presence of any one or more of the above can have their own independent effects and adverse influences on the patient and their overall well-being, as well as interact with and negatively affect those problems dealing directly with vision and visual information processing. These latter may include oculomotor deficits (e.g., blur, diplopia) and related reading problems (e.g., skipping lines of text, rereading lines of text), photosensitivity, visual memory problems, and subtle visual field defects (e.g., local reductions in contrast perception), as well as many others. In fact, it is estimated that 15% of individuals having experienced a single concussion will manifest some type of visual disturbance.[6] Related to this, a retrospectively-based study in an academic, clinical setting revealed that 90% of visually-symptomatic (n=160), acquired brain injury patients exhibited an oculomotor-based problem of some type (e.g., accommodative insufficiency, convergence insufficiency, intermittent strabismus).[7] This is supported by a more recent clinical practice, retrospective study in concussion patients.[8] Thus, vision care in this population, both of a diagnostic and therapeutic nature, is critical for a patient's recovery and reintegration into society as a productive individual.

A detailed case report of a young-adult having sustained several sports-related concussions is presented. Its unique aspects are: the severity of the consequences following these concussions; the detailed and successfully employed diagnostic protocol and therapeutic program of combined conventional optometric vision therapy, spectacle correction, and spectral tint; and the long-term, follow-up period.

CASE SUMMARY

The patient was a 20-year-old, male, college student who presented for a "visual efficiency and visual information processing" evaluation at the second author's private optometric practice. He was referred by a medical concussion specialist based on a detailed case history, physical examination, and related symptoms. At the time of presentation, he had suffered six medically-documented sports-related concussions, all involving hockey, over the past six years, with the most recent one occurring four months prior to the current vision evaluation. The patient indicated that he had fully recovered from the first five concussions. His symptoms now included daily headaches, as well as photosensitivity especially to fluorescent illumination. He also experienced general asthenopia, intermittent horizontal diplopia, and loss of place while reading. Presence of these phenomena caused difficulty with reading in general, reading comprehension, computer work, and completing class assignments. In fact, these symptoms became so severe that he was subsequently forced to take a one semester leave of absence during his junior year at college. We had performed our vision evaluation in the summer between his sophomore and junior year at college. A summary of the relevant vision findings is presented in Table 1.

Table 1. Summary of initial visual findings.

Test	Vision Exam Result	Normal Range	Interpretation
Best corrected visual acuity (Snellen)	OD 20/20 OS 20/20	20/20	Normal
Refractive Status (dry manifest)	OD Plano-0.50x105 OS Plano-0.75x072	N/A	OD Astigmatism OS Astigmatism
Distance Phoria (von Graefe)	Orthophoria	0-2 exophoria	Normal
Near Phoria (von Graefe)	5 exophoria	0-6 exophoria	Normal
Nearpoint of Convergence (accommodative target)	6" break/10"recovery	1-3" break/3-5" recovery	Convergence Insufficiency
Near Convergence Range (von Graefe)	X/10/6	17/21/11	Convergence Insufficiency
Near Divergence Range (von Graefe)	8/16/12	13/21/13	Fusional Instability
Vergence Facility (3pd BI/12pd BO)	10 cpm (fails BO)	15 cpm	Convergence Insufficiency
Accommodative Facility (+/- 2.00D)	OD 12 cpm OS 12 cpm	12 cpm	Normal
Stereopsis (Wirt circles)	20 seconds	20 seconds	Normal
Visagraph Reading Eye Movement Test (Level 10)	5.0 grade level efficiency	12.0 or greater grade level	Oculomotor Dysfunction

DIAGNOSES

There were multiple visual diagnoses (Table 1). First, despite his unaided visual acuity of 20/20 in each eye, he exhibited a low amount of symptomatic, uncorrected, astigmatism bilaterally based on a non-cycloplegic refraction. Second, he had a reduced near point of convergence (with repetition), as well as reduced positive and negative relative, horizontal, vergence ranges at near. Third, based on the Visagraph Reading Eye Movement Test (level 10), his grade-level efficiency placed him at the fifth-grade level. Fourth, he exhibited disequilibrium (visual vertigo) when stimulated with a peripheral optokinetic drum.[9] And, lastly, he reported photosensitivity, especially with fluorescent illumination. Based on these findings, he was diagnosed with low myopic astigmatism, convergence insufficiency, fusional instability, oculomotor dysfunction, and photosensitivity.

Table 2. Examples of vision therapy techniques used in each phase of treatment.

Visual Stabilization	Binocular Vision Integration	Visual Automaticity
Brock string	Brock string with prism flippers, +/- lenses	Neuro-vision Rehabilitator (NVR) with multi-sensory integration
Pointer in straw	Binocular accommodative rock with red/ green bar reader	Phase 2 activities incorporating VOR, balance board, and metronome
Clown vectogram	BOP/BIM with quoits/ clown double vectograms	
Computer RDS	Dynamic reader/ visual search and scan with prism and accommodative flippers	
Monocular accommodative rock	Aperture rule with look away	Alternating BI and BO Aperture Rule
Monocular near-far Hart chart	RDS jump ductions (near, intermediate, distance projected)	
MFBF tracking/scan	Stereoscope cards	
Red rock anti-suppression technique	Red Rock with +/- lenses	
Hart chart saccades Michigan tracking	Michigan tracking with +/- lenses, prism flippers	Michigan tracking with +/- lenses, prism flippers, and added metronome
Marsden ball pursuit activities	Marsden Ball with split pupil accommodative rock	Marsden Ball with balance board
PTS II Visual Search and Scan	With Red-Blue glasses	Faster speeds, adding to the number of stimuli and distractors

TREATMENT PLAN

The basic treatment plan was as follows. He was prescribed a spectacle correction for his astigmatism, as well as his subjectively-preferred bluish-purple tint (BPI Omega) to alleviate the photosensitivity. He was also prescribed a regimen of conventional optometric vision therapy. This included 2 sessions per week of in-office vision therapy (45 minutes each session) for 12 weeks. No home vision therapy was performed during this time. The goal was to improve accommodation, vergence, and versional eye movements, as well as higher-level visual processing skills, selective and sustained attention (e.g., computerized visual scan and tachistoscope), and visual-vestibular interaction (e.g., walking with a hand-held stereoscope).

More specifically, the vision therapy was divided into three phases, each with a specific goal.[10] See Table 2 for some of the primary techniques incorporated during each phase of vision therapy.

Phase 1: Visual Stabilization: Initial therapy began with procedures to develop monocular oculomotor and accommodative ability. The therapy procedures also served to stabilize the vergence system at both distance and near. The eventual goal with these procedures was to normalize positive and negative, relative, horizontal vergence ranges, as well as the accommodative amplitude and its dynamic facility, without any fatigue effects.

Table 3. Summary of visual findings pre-vision therapy, post- vision therapy, and 3 year's post-vision therapy.

Test	Pre-Vision Therapy	Post-Vision Therapy	3 years Post-Vision Therapy
Best corrected visual acuity (Snellen)	OD 20/20 OS 20/20	OD 20/20 OS 20/20	OD 20/20 OS 20/20
Refractive Status (dry manifest)	OD Plano-0.50x105 OS Plano-0.75x072	No change	OD -0.25-0.50x100 OS -0.25-0.50x70
Distance Phoria (von Graefe)	1pd exophoria	1 pd exophoria	Orthophoria
Near Phoria (von Graefe)	5 pd exophoria	5 pd exophoria	7 pd exophoria
Nearpoint of Convergence (accommodative target)	6" break/ 10"recovery	2" break/3" recovery	2" break/3" recovery
Near Convergence Range (von Graefe)	X/10/6	X/30/18	18/30/26
Near Divergence Range (von Graefe)	8/16/12	X/26/24	14/26/20
Vergence Facility (3pd BI/12pd BO)	10 cpm (fails BO)	14 cpm	15 cpm
Accommodative Facility (+/- 2.00)	OD 12 cpm OS 12 cpm	OD 12 cpm OS 12 cpm	OD 13 cpm OS 14 cpm
Stereopsis (Wirt circles)	20 seconds	20 seconds	20 seconds
Visagraph Reading Eye Movement Test (Level 10)	5.0 grade level efficiency	12.0 grade level efficiency	Not performed

Phase 2: Binocular Visual Integration: Treatment emphasized binocular accommodative and oculomotor tasks. The procedures served to improve vergence speed and accuracy. As these tasks were improved and refined, new and more difficult tasks were added requiring the patient to respond to non-congruent (i.e., unequal) vergence and accommodative demands,[11] such as with BOP/BIM.

Phase 3: Visual Automaticity: This final phase served to refine the visual skills as well as to increase response automaticity. To achieve this goal, multi-sensory integration across modalities was incorporated. Such techniques required integration of the vergence, accommodative, vestibular, tactile, and auditory systems, with the goal of increasing the speed, accuracy, and automaticity of visual and visuomotor responses.

OUTCOMES

The patient manifested a wide range of vision improvements at the cessation of the office-based vision therapy. (Table 3). He exhibited total reduction in his visual symptoms, with full-time wear of his tinted, spectacle refractive correction. He no longer experienced either headaches or asthenopia while reading; he was now able to read and study comfortably for longer periods of time (i.e., 60 minutes versus 5 minutes). His visual efficiency based on the objective Visagraph results improved from the fifth to the twelfth grade-level. There was a significant reduction in photosensitivity and disequilibrium as well. Lastly, his near point of convergence, horizontal vergence ranges, and dynamic vergence flipper facility all normalized, and most importantly, remained so at his three-year follow-up vision examination.

DISCUSSION

The role of the optometrist as a key member of the multi-disciplinary, rehabilitative team is essential to improve the overall quality-of-life in patients experiencing residual, post-concussion visual symptoms. In the present case report, this is exemplified by the combined use of prescription lenses, tints, and conventional vision therapy in a successful, multi-pronged, optometric approach. Furthermore, there was long-term persistence (3 years) of the initial positive remediation effects, which to the best of our knowledge is being reported for the first time in the literature.

Many individuals with concussion/mTBI exhibit increased sensitivity to small, uncorrected refractive errors.[4,12] Therefore, it is essential to correct even modest amounts of astigmatism, as done in the present case, as well as more generally for low amounts of myopia, but especially for hyperopia. In the latter case, due to the frequently manifested reduced accommodative ability in this population,[13] the patient may no longer be able to compensate fully and comfortably for any uncorrected hyperopia. Moreover, use of the full refractive correction provides increased clarity of vision in those with impaired contrast perception (e.g., reduced contrast sensitivity),[10] and furthermore it balances the interaction between accommodation and vergence at near,[4] thus resulting in improved binocularity.

The use of a therapeutic tint is frequently another critical component in the management of those patients reporting photosensitivity.[12,14,15] More than 50% of concussion/mTBI patients report the perceptual phenomenon of photosensitivity persisting longer than six months following their injury.[14,15] In the author's practice, the bluish-purple, BPI-Omega tint (www.colorlenses.com) has been found to be particularly beneficial in reducing photosensitivity, especially for the typically problematic fluorescent illumination, as was true for this patient. It has been speculated that spectral filters function to reduce hyperexcitability of the visual cortex,[16] while both spectral and non-spectral filters (e.g., grey neutral density) may act to reduce the luminous intensity of the offensive visual stimuli.[1,4,12] Additionally, standard brown and grey polarized filters may also be helpful in reducing photosensitivity and glare while outdoors, especially in very bright sunlight or with highly-reflective surfaces (e.g., a white concrete surface, sandy beach). Recent evidence has suggested that the least amount of tint density that helps the patient should be prescribed to promote possible long-term, visual adaptation to this aberrant hypersensitivity (i.e. reduced photosensitivity).[15]

Lastly, there is growing evidence, both from the clinic[4,17,18] and the research laboratory using objective recording techniques,[4,5] that vision therapy serves to improves and even normalizes oculomotor system responsivity,[4,5,13] with correlated reduction in visual symptoms,[4,5,13] improved reading ability,[19,20] and enhanced visual attention[21] in these patients. Within the context of vision therapy, which embodies the tenets of perceptual and motor learning[22] and Hebbian neural network principles,[23] there is a conventional, multi-phase approach typically used,[10] as described earlier. First, one stabilizes the monocular aspects of oculomotor control at distance and near. Second, one employs both integration and mismatch of binocular accommodative and vergence/versional, oculomotor aspects to increase the speed and accuracy of the binocular response. Third, one continues to practice the aforementioned visual skills/abilities, so that they become fully habituated with response automaticity/reflexivity, in particular incorporating multisensory modality tasks (i.e., vision, balance, taction, and audition) with progressively higher task demands (i.e., "task-loading").

This case report serves to provide a useful optometric-based, vision remediation protocol and model.[1,10,12,24] It also provides detailed, quantitative, clinical evidence for the presence of considerable visual system plasticity, even in the damaged, young-adult brain. This is consistent with several other recent reports in this area in both younger and older adults with concussion/mTBI.[4,25] The visual sequelae in the concussion patient can be reduced, and even eliminated, following a careful and comprehensive neuro-optometric vision rehabilitative approach, so these individuals can once again become independent and productive members of our society.

REFERENCES

1. Ciuffreda KJ, Ludlam DP, Tannen B. Concussion in the twenty-first century: an optometric perspective. Vis Dev Rehabil 2015; 3: 204-205.
2. Warden D. Military TBI during the Iraq and Afghanistan wars. J Head Trauma Rehabil 2006; 21: 398-402.
3. Pieroth EM, Hanks C. Management of concussion in the professional football player. Prog Neurol Surg 2014; 28: 171-183.

4. Ciuffreda KJ, Ludlam DP, Yadav NK, Thiagarajan P. Traumatic brain injury: visual consequences, diagnosis, and treatment. In Advances in Ophthal and Optom, M. Yanoff (ed.), Elsevier, Philadelphia, 307-333, 2016.
5. Thiagarajan P. Oculomotor rehabilitation for reading dysfunction in mild traumatic brain injury. Ph.D. dissertation, SUNY/Optometry, 2012.
6. Iverson GL. Outcome from mild traumatic brain injury. Curr Opin Psychiat 2005; 18: 301-317.
7. Ciuffreda KJ, Kapoor N, Rutner D, Suchoff IB, Han ME, Craig S. Occurrence of oculomotor dysfunctions in acquired brain injury: a retrospective analysis. Optom 2007; 78: 155-161.
8. Tannen B, Darner R, Ciuffreda KJ, Shelley-Tremblay J, Rogers J. Vision and reading deficits in post-concussion patients: a retrospective analysis. Vis Dev Rehabil 2015; 3: 206-213.
9. Ciuffreda KJ. Visual vertigo syndrome: clinical demonstration and diagnostic tool. Clin Eye Vis Care 1999; 11: 41-42.
10. D'Angelo ML, Tannen B. The optometric care of vision problems after concussion: a clinical guide. Optom Vis Perf 2015; 3: 298-306.
11. Ciuffreda KJ. Components of clinical near vergence testing. J Beh Optom 1992; 1: 3-13.
12. Ciuffreda KJ, Ludlam DP. Conceptual model of optometric vision care in mild traumatic brain injury. J Beh Optom 2011; 22: 10-12.
13. Thiagarajan P, Ciuffreda KJ. Effect of oculomotor rehabilitation on accommodative responsivity in mild traumatic brain injury. J Rehabil Res Dev 2014; 51: 175-191.
14. Digre KB, Brennan K. Shedding light on photophobia. J Neuro-Ophthal 2012; 32: 68-81.
15. Truong JQ, Ciuffreda KJ, Han MH, Suchoff IB. Photosensitivity in mild traumatic brain injury (mTBI): a retrospective analysis. Brain Inj 2014; 28: 1283-1287.
16. Huang J, Zong X, Wilkins A, Bozoki A, Cao Y. fMRI evidence that precision ophthalmic tints reduce cortical hyperactivation in migraine. Cephalagia 2011; 31: 925-936.
17. Ciuffreda KJ, Rutner D, Kapoor N, Suchoff IB et al. Vision therapy for oculomotor dysfunction in acquired brain injury. Optom 2008; 79:18-22.
18. Ciuffreda KJ, Suchoff IB, Marrone MA, Ahmann E. Oculomotor rehabilitation in traumatic brain-injured patients. J Beh Optom 1996; 7: 31-38.
19. Thiagarajan P, Ciuffreda KJ, Capo-Aponte JE, Ludlam DP, Kapoor N. Oculomotor rehabiliataion for reading in mild traumatic brain injury (mTBI): an integrative approach. NeuroRehabil 2014; 34: 129-146.
20. Ciuffreda KJ, Han Y, Kapoor N, Ficarra AP. Oculomotor rehabilitation for reading in acquired brain injury. NeuroRehabil 2006; 21: 9-21.
21. Yadav NK, Thiagarajan P, Ciuffreda KJ. Effect of oculomotor rehabilitation on the visual-evoked potential and visual attention in mild traumatic brain injury (mTBI). Brain Inj 2014; 7: 922-929.
22. Ciuffreda KJ. The scientific basis for and efficacy of optometric vision therapy in non-strabismic accommodative and vergence disorders. Optom 2002; 73: 735-762.
23. Hebb DO. The organization of behavior: a neuropsychological theory. Wiley, New York, 1949.
24. Ciuffreda KJ, Ludlam DP, Yadav NK. Conceptual model pyramid of optometric care in mild traumatic brain injury (mTBI): a perspective. Vis Dev Rehabil 2015; 1: 105-108.
25. Thiagarajan, P, Ciuffreda, KJ. Short-term persistence of oculomotor rehabilitative changes in mild traumatic brain injury (mTBI): a pilot study of clinical effects. Brain Inj. 2015; 1475-1479.

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