

Successful Neuro-Optometric Rehabilitation (NOR) in a Patient with Long-Term Post-Concussion Visual Symptoms

Kelsey J. Moore, OD
Bright Eyes Vision Clinic
Otsego, Minnesota

Barry Tannen, OD, FCOVD, FAAO
Eye Care Professionals, PC
Hamilton, New Jersey

Kenneth J. Ciuffreda, OD, PhD
SUNY/Optomtry
New York, New York

ABSTRACT

Over the past decade, neuro-optometric rehabilitation (NOR) has been demonstrated to improve visual skills and reduce visual symptoms in patients with mild traumatic brain injury (mTBI)/concussion. In the present case report in an adolescent with a sports-related

Correspondence regarding this article should be emailed to Barry Tannen, OD, FCOVD, FAAO, at btannenod@aol.com. All statements are the authors' personal opinions and may not reflect the opinions of the College of Optometrists in Vision Development, Vision Development & Rehabilitation or any institution or organization to which the authors may be affiliated. Permission to use reprints of this article must be obtained from the editor. Copyright 2018 College of Optometrists in Vision Development. VDR is indexed in the Directory of Open Access Journals. Online access is available at covd.org. <https://doi.org/10.31707/VDR2018.4.4.p170>

Moore K, Tannen B, Ciuffreda K. Successful neuro-optometric rehabilitation (NOR) in a patient with long-term post-concussion visual symptoms. *Vision Dev & Rehab* 2018;4(4):170-6.

Keywords: concussion, ImPACT testing, mild traumatic brain injury, neuro-optometric rehabilitation (NOR), photosensitivity, return-to-play, visual motion sensitivity, vision rehabilitation, vision therapy

concussion and a range of related long-term visual symptoms, there are two unique aspects: (1) it details and demonstrates the efficacy of NOR one year post-injury, and (2) it suggests that the results of NOR may be an additional predictor of return-to-play.

INTRODUCTION

The diagnosis and management of concussion, a type of mild traumatic brain injury, has been an increasingly important area in optometric care.¹ Awareness of post-concussion syndrome has been made more visible due to increased media coverage and the recognition of sports-related head injury.² Individuals with post-concussion syndrome often manifest a range of visually-based symptoms, including headaches, photosensitivity, reading problems, visual motion sensitivity, intermittent blur, diplopia, and oculomotor deficits such as difficulty with visual tracking.³ Previous studies have estimated that up to 90% of post-concussion patients who remain visually symptomatic for an extended period exhibit some type of versional oculomotor dysfunction, vergence problem, and/or accommodative deficit.^{4,5,6} Therefore, proper vision assessment and care in this population is crucial for recovery and a good quality-of-life (QOL).

Often times, sports medicine specialists are on the front lines of assessing these patients following their acute-phase concussion, and then throughout their recovery.^{7,8} One tool that is commonly used in the athletic community to assess the concussive status and track recovery is the Immediate Post Concussion Assessment and Cognitive Testing (ImPACT). ImPACT involves a series of neurocognitive tests that were specifically developed to evaluate areas of possible deficit in sports-related concussions.⁷ These include several areas, such as attention span, motor processing speed, reaction time, working memory, non-verbal problem solving, and impulse control. ImPACT is also widely used as a tool to decide return-to-play.⁸

This case report details the neuro-optometric evaluation and rehabilitation as an additional tool to assess visual recovery and return-to-play. It demonstrates the success of NOR to reduce longstanding, post-concussion visual symptoms. The unique aspects of this case include the long duration for which the patient was visually symptomatic prior to the initiation of NOR, as well as the possible limitation of ImPACT testing alone in the determination of return-to-play.

CASE SUMMARY

"MF" was a 17 year-old-female who presented to our office for a neuro-optometric evaluation by referral of a sports medicine physician. The patient had suffered a concussion 12 months prior to her neuro-optometric evaluation, which was her first and only diagnosed concussion. The incident occurred while playing soccer, when she collided in midair with another player, and then lost consciousness for one minute. The next day she was diagnosed with a concussion by a sports medicine physician. At that visit, she completed her first post-concussion ImPACT test, which she failed solely due to slow reaction time compared to her baseline (pre-injury) ImPACT. Prior to her appointment with our office, the patient had completed a formal physical therapy and a formal vestibular therapy program, which did not alleviate her post-concussion vision symptoms. She was cleared for non-contact sports and related exercise activities three months after the concussion.

When reading, MF reported that the letters appeared to move, shimmer, and jump on the page, and sometimes double. MF used to love to read, but since the concussion she no longer did. She now skipped lines, read more slowly, and lost her place more often when reading than prior to her concussion. MF experienced headaches most of the time. In the morning, her headaches were a 2-3 on a scale of 10, and they increased to a 5-6 throughout the day. Her headaches were exacerbated with reading, presence of background noise, and when in busy visual environments (e.g., crowded

school hallways, malls, etc.). The headaches were localized over her eyes and temples. Additionally, busy visual environments caused MF to become nauseous, which did not occur prior to the concussion. However, MF had a long history of motion sickness, which worsened since the concussion.

A complete neuro-optometric evaluation was performed, which included pupil, visual field, tonometry, biomicroscopy, and fundus examination. The results of these specific tests were unremarkable. A summary of the remaining aspects of the vision evaluation is included in Table 1, with all but two of the findings being outside of normal limits.

At the initial evaluation, the COVID Quality-of-Life (QOL) survey was also administered. Her score was 46, which indicated the presence of considerable visual symptoms. Furthermore, only nine of the thirty question responses were in the "never" or "seldom" category. The survey has been used as a tool to assess impediments to academic performance and demonstrate the effectiveness of vision therapy.⁹ The COVID-QOL survey shows promise as a quantitative measure of post-concussion syndrome, as well as a pre/post-NOR measure of progress.⁹

DIAGNOSIS

There were multiple abnormal clinical signs and visual diagnoses made at the initial assessment (Table 1). For example, MF exhibited a receded near point of convergence, as well as reduced convergence and divergence fusional ranges at both distance and near, and other related deficits. Additionally, based on the Visagraph Reading Eye Movement Test,¹⁰ which was administered at the reading level,¹⁰ her eye movement-based reading efficiency placed her at a first-grade reading level (Table 2). All of the findings were well outside the expected age norms. In contrast, the DEM findings before and after NOR were all within the normal limits (Table 3).

MF also reported general and visual discomfort when tested with an optokinetic nystagmus

Table 1: Summary of initial vision findings.

Test	Initial Exam Result	Normal Range	Interpretation
Refractive Status	OD: Plano 20/25+2 OS 20/25+2 OD: Plano J1 OS J1 Add: +0.50D	20/20	Mildly Reduced Visual Acuity
Distance Phoria (cover test)	ortho	ortho-2 pd exophoria	Normal
Near Phoria (cover test)	3 pd esophoria	0-6 pd exophoria	Fusional Instability
Nearpoint of Convergence (accommodative target)	4" break / 7" recovery	1-3" break / 3-5" recovery	Convergence Insufficiency
Near Convergence Ranges	10/14/6 pd	17/21/11 pd	Convergence Insufficiency
Near Divergence Ranges	12/16/10 pd	13/21/13 pd	Fusional Instability
Distance Convergence Ranges	4/6/0 pd	9/19/10 pd	Fusional Instability
Distance Divergence Ranges	x/6/2 pd	x/7/4 pd	Fusional Instability
Vergence Facility (12pd BO/3pd BI)	3 cpm, fails BO	15 cpm or greater	Convergence Insufficiency
Distance Fusional Facility (4pd BO/2pd BI)	3 cpm, fails BI	15 cpm or greater	Fusional Instability
Accommodative Facility (+/- 2.00D)	RE: 2 cpm, fails plus LE: 5 cpm, fails plus	12 cpm or greater	Accommodative Infacility
Accommodative Amplitude (Minus lens)	RE: 7.50 D LE: 6.50 D	10.50 D or greater	Accommodative Insufficiency
Pursuit Eye Movements	+2 w/ head movement	+3	Oculomotor Dysfunction
Saccadic Eye Movements	+2	+3	Oculomotor Dysfunction
Visagraph Reading Eye Movement Test (Level 10)	1.0 grade level efficiency	12.0 grade level efficiency	Oculomotor Dysfunction
Developmental Eye Movement Test (DEM)	Ratio: 47th %ile Errors: 61st %ile	38th %ile	Normal
Test of Silent Word Reading Fluency	5th %ile	38th %ile	Possible Reading Fluency Deficit
Simultaneous Visual Memory: Tachistoscope	13th %ile	38th %ile	Simultaneous Visual Memory Deficit
Sequential Visual Memory: Visual Span	38th %ile	38th %ile	Normal

Table 2: Visagraph Results Before and After NOR

Parameter	Before	After
Fixation/100 words	261	84
Regressions/100 words	76	10
Ave. Span of Recognition	0.38	1.19
Ave. Duration of Fixation (sec)	0.28	0.23
Rate with Comprehension (words/min)	80	300
Grade Level Efficiency	1.0	13.4
Level of Text Read	10	10
Comprehension	90%	100.00%

Table 3: DEM Scores Before and After NOR

Parameter	Before	After
Vertical (A+B)	35 sec	25 sec
Horizontal	40 sec	26 sec
Horizontal Errors	1	0
H/V Ratio	1.13	1.04

drum rotated in her peripheral visual field, which created Gibsonian optic flow.^{11,12} She also reported specific photosensitivity, including increased symptoms in fluorescent lighting and while viewing computer screens. Based on these findings, MF was diagnosed with convergence insufficiency, fusional instability, oculomotor dysfunction, accommodative insufficiency, accommodative infacility, visual motion sensitivity, and photosensitivity.

Treatment Plan

For her treatment plan, MF was prescribed a spectacle correction for near vision, as well as a BPI Omega tint (85% transmission). This tint alleviated a degree of her visual motion sensitivity and much of her specific photosensitivity

Table 4. Examples of NOR techniques used in each phase of treatment.

Phase 1: Visual Stabilization	Phase 2: Binocular Visual Integration	Phase 3: Visual Automaticity
Monocular Accommodative Rock	Binocular Accommodative Rock with red/green bar reader	Phase 2 activities incorporating VOR, balance board and metronome
Monocular Near-Far Hart Chart	Near-Far Hart Chart Decoding	Syntonics and OPT Light Therapy
Brock String, Beading for Convergence	Brock String with prism flippers, +/- lenses	Alternating BI and BO Aperture Rule with VOR
Vectograms Extension of Ranges (Quoits, Clown)	Vergence Jumps with Double Vectograms (Quoits and Clown)	Aperture Rule with look-aways
Computer RDS (VTS3, HTS)	RDS jump ductions (near, intermediate, distance projected)	BOP/BIM with Vectograms, and computer RDS
Marsden Ball Pursuit Activities	Marsden ball with yoked prism	Michigan Tracking with +/- lenses, prism flippers, and added metronome
Hart Chart Saccades, Michigan Tracking	Michigan tracking with +/- lenses, prism flippers	ACE Reader Span
MFBF tracking/scan	MFBF Visual Search and Scan	Sanet Visual Integrator (SVI) with multisensory integration
PTS II Visual Search and Scan	Dynamic Reader / Visual Search and scan with prism and accommodative flippers	Faster speeds, adding to the number of stimuli and distractors

Table 5: Pre-Post-NOR findings.

Test	Pre VT	After 12 VT Sessions	Post VT (21 Sessions)
Distance Phoria (cover test)	ortho	ortho	ortho
Near Phoria (cover test)	3 pd esophoria	3 pd esophoria	3 pd esophoria
Nearpoint of Convergence (accommodative target)	4 inches	2 inches	1 inch
Near Convergence Range	10/14/6 pd	18/22/10 pd	24/36/20 pd
Near Divergence Range	12/16/10 pd	12/24/12 pd	16/26/16 pd
Distance Convergence Range	4/6/0 pd	x/6/1 pd	12/18/10 pd
Distance Divergence Range	x/6/2 pd	x/8/4 pd	x/10/6 pd
Vergence Facility (12pd BO/3pd BI)	3 cpm, fails BO	14 cpm	25 cpm
Distance Fusional Facility (4pd BO/2pd BI)	3 cpm, fails BI	9 cpm	22 cpm
Accommodative Facility (+/- 2.00D)	RE: 2 cpm, fails plus LE: 5 cpm, fails plus	RE: 10 cpm LE: 11 cpm	RE: 16 cpm LE: 17 cpm
Accommodative Amplitude (Minus lens)	RE: 7.50 D LE: 6.50 D	RE: 8.50 D LE: 9.00 D	RE: 11.00 D LE: 11.50 D
Pursuit Eye Movements	+2 w/ head movement	+4	+4
Saccadic Eye Movements	+2	+4	+4
Visagraph Reading Eye Movement Test (Level 10)	1.0 grade level efficiency	—————	13.5 grade level efficiency
Developmental Eye Movement Test (DEM)	Ratio: 47th %ile Errors: 61st %ile	—————	Ratio: 75th %ile Errors: 77th %ile
Test of Silent Word Reading Fluency	5th %ile	—————	63rd %ile
Simultaneous Visual Memory: Tachistoscope	13th %ile	—————	25th %ile
Sequential Visual Memory: Visual Span	38th %ile	—————	88th %ile
Quality of Life Symptom Survey	46	—————	15

symptoms. She was also prescribed a program of NOR. It was administered in-office and consisted of 40 minute sessions, twice per week. She completed 21 sessions over a period of 12 weeks (16 hours total). Home NOR using similar techniques was dispensed

upon the completion of her in-office sessions. The goal of the NOR was to improve vergence, accommodation, visual-vestibular integration, high-level visual processing, and selective and sustained visual attention.

Her NOR plan was divided into three phases, each with its own goal.^{13,14} This plan is outlined in Table 4. In phase 1, the goal is visual stabilization. In this initial stage, the therapy focuses on building monocular accommodative and oculomotor skills. More basic binocular skills are trained as well. This includes divergence and convergence ranges at both distance and near, and working toward rapid, symptom-free, vergence facility ability. There were no adverse effects or symptoms during this monocular training phase. In phase 2, the goal is binocular visual integration. This phase focuses on binocular accommodative facility and amplitude, as well as binocular oculomotor skills. In the later stages of phase 2, integrative accommodative and vergence tasks are added, such as BIM/BOP, to work towards visual automaticity, which is the ultimate goal of phase 3. This final phase involves integration of the visual system with multiple sensory systems, such as auditory, vestibular, tactile, with progressively higher demands, and executed with automaticity.

Re-Evaluations and Outcomes

After the first 12 NOR sessions, the patient passed the post-ImPACT test for the first time since her concussion. However, our optometric testing indicated that visual recovery was not complete (Table 5); furthermore, while MF's symptoms had lessened, she still remained visually symptomatic. In consultation with her sports medicine physician, the patient was advised not to return-to-play at that time.

At the completion of the 21 sessions of vision therapy, however, her clinical visual findings improved dramatically (Table 5), with marked reduction of symptoms as assessed by the COVD-QOL survey. Her score was now reduced to 15, which suggested being relatively symptom free. Additionally, nearly all question responses (28 out of 30) were in the "never" or "seldom" category. And, all of her Visagraph findings were now in the expected age norms (Table 2). She was then cleared for unrestricted

return-to-play by both her sports medicine physician and us.

Ten weeks after the completion of NOR, MF's clinical findings remained similar to her initial post-NOR results. She reported that her reading comprehension score on the SAT now improved by 50 points, and her post-concussion visual symptoms had completely resolved.

DISCUSSION

Current post-concussion, return-to-play protocols alone may not be sufficient to assess adequately post-concussion visual recovery. After passing her post-concussion ImPACT testing, and being cleared to play by her sports medicine physician, MF was still visually-symptomatic, and her sensorimotor visual skills remained impaired. Based on this information, her sports medicine physician delayed return-to-play after consulting with us. This is consistent with the patient having several risk factors for a second concussion, such as gender, age, type of sport, and history of a concussion, with the last factor being the best predictor for getting a subsequent concussion.^{15,16} Interestingly, this is consistent with the theme and message of the present paper.

After an additional nine NOR sessions focusing on binocular integration and visual automaticity, MF was now symptom-free with normalized visual findings. Neuro-optometric evaluation and the NOR results have the potential to predict a more complete and global recovery, at least in some patients. Thus, we suggest it be used in concert with neuro-psychological tools such as ImPACT. This is logical when the high prevalence of symptomatic visual deficits after concussion is considered.^{5,17}

There is growing evidence that NOR can improve/normalize visual skills and significantly reduce symptoms in patients following mild traumatic brain injury, such as concussion.³ It is important to note that in the present case, the patient consistently suffered from post-concussion, visual symptoms for one year prior to NOR. Nonetheless, the three-phase approach

of the NOR was very successful in eliminating the post-concussion visual symptoms and normalizing the clinical visual findings.¹¹ The present findings, as well as other positive laboratory studies and clinical trials,¹⁸⁻²³ suggest there may be no post-injury time limit to obtain some degree of visual recovery. Further research in this important area is needed, especially longitudinal ones using objective recording techniques of vision function. This case illustrates the frequent persistence of post-concussion visual symptoms, the robust nature of NOR in treating these patients, and the new potential role of NOR in determining return-to-play.

Lastly, it is interesting to speculate that NOR may have a “neuro-protective effect (NPE)” on the human visual system. In its general usage, a NPE refers to some early intervention (e.g., pharmacologic) that slows or even reverses neural loss at the cellular level over time,²⁴ thus preserving some degree of structure and function that might otherwise be lost. How might this concept be broadly applied to the visual system in these patients? We speculate that when NOR is introduced as an early and aggressive intervention, it may act to reduce, or even prevent, the adverse visual consequences of a subsequent concussion. That is, NOR may make the concussed individual more “resistant/resilient” to, and thus reduce the risk of, any new visual sequellae from a subsequent concussion. For example, assume that the adverse visual effect of the original concussion was primarily a vergence dysfunction, such as convergence insufficiency. Then the goal of NOR would be to exceed the standard, normal clinical vergence parameters, such as horizontal vergence ranges at near, by 50% or more. Hence, when a subsequent concussion occurs, the effect on the vergence system might now be reduced or even non-existent. For example, following the new insult, the formerly 150% performing vergence system would now be reduced to 120% but not below 100%, and thus without the occurrence of any new visual symptoms. This novel idea

requires further clinical and laboratory testing for confirmation.

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. Pieroth EM, Hans C. Management of concussion in the professional football player. *Prof Neurol Surg* 2014; 28: 171-183.
3. Ciuffreda KJ, Ludlam DP, Yadav NK, Thiagarajan P. Traumatic brain injury: visual consequences, diagnosis and treatment. In: *Advances in Ophthalmology and Optometry*, M. Yanoff (ed.), Elsevier, Philadelphia, 307-333, 2016.
4. 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.
5. 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.
6. Tannen B, Good K, Ciuffreda KJ, Moore KJ. Prevalence of esophoria in concussed patients. *J Optom* 2018; DOI: 10.1016/j.optom.2018.02.003.
7. Harmon KG, Drezner JA, Gammons M Endorsed by the National Trainers’ Athletic Association and the American College of Sports Medicine, et al. American Medical Society for Sports Medicine position statement: concussion in sport. *Br J Sports Med* 2013;47:15-26.
8. Lovell M, Collins M, Bradley. Return-to-play following sports-related concussion. *J Clin Sports Med* 2004; 23(3):421-41.
9. Bleything WB, Landis SL. Effectiveness of the College of Optometrists in Vision Development – QOL questionnaire in a socially at risk population of youth. *Optom Vis Dev* 2008;39:82-90.
10. Tannen B, Ciuffreda K. A proposed addition to the standard protocol for the Visagraph II eye movement recording system. *J Behav Optom* 2007; 18(6): 143-147.
11. Ciuffreda KJ, Yadav NK, Ludlam DP. Binocular occlusion (BNO), visual motion sensitivity (VMS), and the visually-evoked potential (VEP) in mild traumatic brain injury and traumatic brain injury (mTBI/TBI). *Brain Sci* 2017; 7: 98, doi:10.3390/brainsci7080098.
12. Ciuffreda KJ. Visual vertigo syndrome: clinical demonstration and diagnostic tool. *Clin Eye Vis Care* 1999; 11: 41-42.
13. D’Angelo M, Tannen B. The optometric care of vision problems after concussion: A clinical guide. *Optom Vis Perf* 2015;3:298-306.
14. Tannen NM, Tannen B, Ciuffreda KJ. Optometric management of a post-concussion patient: a case report. *Vision Dev Rehabil* 2016;2:237-42.

15. Scopaz KA, Hatzenbuehler JR. Risk modifiers for concussion and prolonged recovery. *Sports Health* 2013;5:537-541.
16. Abrahams S, McFie S, Patricios M, Posthumus M, September AV. Risk factors for sports concussion: an evidence-based systematic review. *Br J Sports Med* 2014;48:91-97.
17. Master, CL, Scheiman M, Gallaway M, Goodman A, Robinson RL, Master SR, Grady MF. Vision diagnoses are common after concussion in adolescents. *Clinical Pediatrics* 2016; 55(3):260-267.
18. Thiagarajan P, Ciuffreda, KJ. Effect of oculomotor rehabilitation on accommodative responsivity in mild traumatic brain injury. *J Rehabil Res Dev* 2014;51:175-191.
19. Thiagarajan P, Ciuffreda KJ. Effect of oculomotor rehabilitation on vergence responsivity in mild traumatic brain injury. *J Rehabil Res Dev* 2013;50:1223-1240.
20. 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;29:1475-1479.
21. Scheiman M, Talasan H, Mitchell GL, Alvarez TL. Objective assessment of vergence after treatment of concussion-related CI: a pilot study. *Optom Vis Sci* 2017;94:74-88.
22. Conrad JS, Mitchell GL, Kulp MT. Vision therapy for binocular dysfunction post-brain injury. *Optom Vis Sci* 2017; 94:101-107.
23. Gallaway M, Scheiman M, Mitchell GL. Vision therapy for post-concussion vision disorders. *Optom Vis Sci* 2017;94:68-73.
24. Dutca LM, Stasheff SF, Hedberg-Buenz A, Rudd DS, Batra N, et al. Early detection of subclinical vision damage after blast-mediated TBI enable prevention of chronic visual deficit by treatment with P7C3-5343. *Invest Ophthal Vis Sci* 2014;55:8330-8341.



**CORRESPONDING
AUTHOR BIOGRAPHY:
Barry Tannen, OD, FCOVD, FAAO**

Hamilton Square, New Jersey
1978, Colgate University, Biology
1982, Pennsylvania College of Optometry
Private Practice, Hamilton Square,
New Jersey
Associate Clinical Professor,
SUNY College of Optometry

Program Supervisor, Vision Therapy and Neuro-Optometric
Rehabilitation Residency (Southern College of Optometry)

Weds, Feb. 20
FULL DAY COURSE

COVD @ SECO

Creating an Efficient, Successful Vision Therapy Program in a Primary Care Office

Presented by Brenda Montecalvo, OD, FCOVD

Millions of patients need YOU! - to help them achieve either in school, on the job, or at work. You can help them by providing a cutting edge vision therapy program in your primary care office. Easy to use chairside activities along with setting up a turnkey in-office vision therapy program will be covered. Content is pertinent for ODs, allied health professionals and optometric staff.

Register now!

**Build Your Own Package
- use the code "COVDSECO"
to waive the registration fee!**



www.covd.org



COLLEGE OF
OPTOMETRISTS IN
VISION DEVELOPMENT