Article ▸ Tolerability and Effectiveness of Contact Lenses in Mild Traumatic Brain Injury with Visual Discomfort: A Case Series

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ABSTRACT

Background: Over one million people in the United States annually have traumatic incidents that lead to traumatic brain injury (TBI). Asthenopia or eyestrain is frequently a clinical complaint with TBI patients. However, little is studied or known in the literature about the potential of contact lens correction in the management of mild TBI (mTBI) with accommodative dysfunction. This pilot study examines the tolerability, effectiveness, and clinical utility of multifocal contact lenses in a subset of mTBI patients with visual discomfort.

Methods: This was a controlled, crossover study using Proclear EP Multifocal contact lenses, compared to Proclear Single Vision contact lenses, for five subjects between the ages of 24 and 31 years of age with history of mTBI. Visual symptoms were evaluated using the Convergence Insufficiency Symptom Survey. Visual function was examined by standard visual tests, including visual acuity, extraocular motility (EOM), pupil size, near point of convergence (NPC), vergence, phoria, NRA/PRA, accommodative and vergence facility, and stereoacuity. Subjects were randomized to wear either Proclear Sphere (single vision) or Proclear EP Multifocal contact lenses, each for a duration of two weeks.

Results: Five mTBI subjects were enrolled in the study. Comprehensive vision examinations of all subjects prior to the study revealed normal ocular health with the exception of visual symptoms such as eyestrain and headache. Two subjects appreciated the beneficial effects of multifocal contact lenses. The other three subjects did not experience substantial benefits of multifocal contact lenses. Nevertheless, all subjects successfully tolerated daylong contact lens wear.

Conclusions: Most eye care professionals face the daunting task of how best to manage complex mTBI cases. One of the lingering effects of TBI is often visual symptoms due to oculomotor dysfunction. Multiple treatment modalities may be necessary to alleviate chronic visual discomfort secondary to mTBI. Traditionally, spectacles, prisms, and vision therapy have been recommended to manage mTBI visual symptoms, but our results suggest that multifocal contact lenses can also be of benefit for a subset of mTBI patients.

Keywords: asthenopia, contact lenses, multifocal contact lenses, accommodative dysfunction, oculomotor dysfunction, traumatic brain injury

Background

Traumatic brain injury (TBI) is caused by trauma or an external force to the head, resulting in either an open- or closed-head injury.[1] TBI is a major subset of acquired brain injury (ABI), which also includes sudden internal insults to the brain, such as stroke and brain tumor.[2]

Over one million people in the United States have traumatic incidents that lead to TBI annually. Most moderate-to-severe cases require immediate medical attention in the emergency room or hospitalization. Although the incidence of TBI has been reported by the Centers for Disease Control (CDC) as 341/100,000 based upon hospital data, a recent hospital record study found the incidence to be much higher: 558/100,000 using the CDC data-system approach.[3] For mild TBI (mTBI), CDC data likely underestimates true prevalence because many individuals who sustain mTBI do not receive medical care at the time of the injury. It is unknown how many of these individuals later present to a medical provider days, weeks, or even months after the injury with complaints of persistent symptoms.[4]

After the acute stabilization period following moderate or worse brain injury, many individuals still need long term

medical and rehabilitative care.[5] Moreover, at least five million Americans with prior history of TBI continue to need long-term assistance in carrying out activities of daily living (ADL).[6] The cause of TBI in the young is different than that in the older population. The majority of TBI in the young (< 25 years) is caused by sports injury or motor vehicle accidents, whereas in the elderly (> 65 years), falls are the major contributor.[5] Additionally, with the recent wars in Iraq and Afghanistan, thousands of military personnel have returned home with varying severity and etiologies of TBI over the past decade.[7]

The eyes are extensions of the brain, so when the brain is affected, more often than not visual function is compromised.[8] Coup-contracoup impact in closed-head injury leads to more generalized axonal damage than open-head injury.[8-10] Therefore, patients with closed-head injury often present with a wide range of neurological deficits including visual symptoms (blur, eyestrain, avoidance of near tasks, intermittent diplopia, headache, etc.) which are well recognized.[11,12] The binocular anomalies found in TBI can largely be attributed to disruption of the accommodative and vergence systems. Recently, a conceptual model has been proposed by Ciuffreda and Ludlam[13] to make the tasks of diagnosis and management of mTBI cases less daunting and more pervasive. In this model, spectacles, prisms, and vision therapy have been recommended, but contact lens correction was not included. Moreover, little has been studied or known in the literature about the potential of contact lens correction in the management of mTBI with accommodative dysfunction.

Multifocal contact lenses are similar to progressive spectacles. They incorporate different lens powers for near and far and thus optimize both distance and near eyesight clarity. In addition to presbyopia, bifocal/multifocal lenses have also been prescribed for younger individuals with symptoms of binocular anomalies, such as convergence excess or accommodative insufficiency, similar to bifocal spectacles. Persistent and long-standing visual discomfort or eyestrain has been widely documented as a consequence of brain injury.[11,12] Many of the factors contributing to reported eyestrain are poorly understood in brain-injured individuals. However, a common secondary effect of TBI is diminished focusing ability and a loss of overall visual adaptability. Given the reduced focusing ability following TBI, multifocal/bifocal lenses would seem a logical treatment option. Having another lens correction modality (other than bifocal spectacles or multiple pairs of single vision glasses) would be advantageous for the brain-injured patient. However, multifocal spectacle lens application has been widely discouraged by TBI vision experts. According to clinical wisdom, TBI patients are more visually hypersensitive and do not adapt well to the complex optics of bifocal and multifocal spectacle lenses, even when they have successfully worn them prior to the TBI.[2]

If the general rule is that TBI patients do not adapt well to bifocal spectacle lens correction, then how successful could we expect multifocal contact lens correction to be? Pre-existing concerns are that TBI patients will not tolerate these contact lenses well, and even if they can, they might not remember to care for them properly.[14]

However, contact lenses have not been investigated as an option. Thus, the primary purpose of this study is to explore and evaluate the tolerability, effectiveness, and clinical utility of multifocal (MF) versus single vision (SV) contact lenses for a select group of mild TBI patients with visual discomfort.

Methods

This was a controlled, crossover clinical trial of tolerability, effectiveness, and safety of Proclear EP Multifocal Contact Lenses (CooperVision Inc., Fairport, NY) compared to single vision Proclear Contact Lenses (CooperVision Inc., Fairport, NY). The Proclear EP Multifocal Contact Lens (Omafilcon A) is a soft hydrophilic contact lens characterized by a front surface asphere consisting of multiple aspheric zones with a spherical base curve. The most plus power is in the center of the lens, progressing to more minus in the periphery. The Proclear multifocal contact lens material was made specifically for people with dry eyes. All Proclear lenses are made up of 62% water, which makes a very high water content lens. Add powers are for patients with up to +1.25 ADD. Subjects who were recruited for this study were between the ages of 24 and 31 years of age with a self-reported history of TBI and who presented with symptoms of eyestrain, visual discomfort, visual fatigue, or visual stress. All subjects satisfied the study inclusion requirement for visual acuity (20/25 or better in each eye at distance and near), refractive error (sphere +/- 6.00D, astigmatism up to -2.50D), no eye disease, and willingness to wear the study contact lenses daily for at least eight hours per day for at least one month.

Individuals who did not meet the above inclusion criteria or who were pregnant, lactating, or breast-feeding at the time of enrollment were excluded from the study. The study protocol was reviewed and approved by the Pacific University Institutional Review Board for Human Subjects. The study adhered to the ethical principles set out in the Declaration of Helsinki. Each participant was informed about the study, underwent a visual and medical history screening, and signed an informed consent form prior to enrolling in the study.

Figure 1 shows the experimental design for the study. Visual symptoms were evaluated using the Convergence Insufficiency Symptom Survey (CISS), which consists of 15 questions and has been shown to be a valid and reliable clinical instrument with convergence insufficiency patients. A CISS score of 21 or higher has been previously validated to discriminate symptomatic adults with convergence insufficiency from those with normal binocular vision.[15] Patient satisfaction with the contact lens was assessed by a Satisfaction Questionnaire (SQ), which consists of one question on each of five items with a 1-to-10 Likert scale.

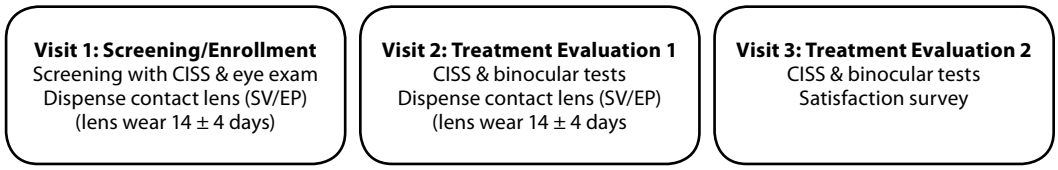

Figure 1: *Experimental design. Subjects are randomized to Proclear single vision or multifocal (EP) contact lens on visit #1, then crossover assignment is done on visit #2.*

Table 1: Visual function data for case # 1

Procedure	Baseline	Single Vision	Multifocal EP
Visual Acuity	16	17	16
Contact Lens Rx	Pl, -0.25	Pl, -0.25	Pl, -0.25
CISS	29	20	6
Cover test (D/N)	0/0	0/0	0/0
NPC	7/9	7/10	4/6
Vergence Supra (D)	(Br/R) 2/0	4/1	3/1
Vergence Infra (D)	(Br/R) 2/0	4/1	3/1
Divergence (D)	(Bl/Br/R) 10/12/9	8/12/6	6/12/5
Convergence (D)	(Bl/Br/R) 12/26/8	18/30/12	12/26/10
Vergence Supra (N)	(Br/R) 3/1	4/1	3/1
Vergence Infra (N)	(Br/R) 3/1	4/1	3/1
Divergence (N)	(Bl/Br/R) 12/24/12	18/24/12	12/20/8
Convergence (N)	(Bl/Br/R) 18/20/6	12/32/6	14/36/6
NRA	(Br/R) 2.75/2.5	2.5/2.25	3/2.5
PRA	(Br/R) -2.5/-2.25	-4.5/-4	-3.75/-2.5
Accom Fac (+/- 1.5D)	(10cyc) 35.44 sec	31.78	36.37
Vergence Fac (8BI)	33 sec	70	43
Vergence Fac (8BO)	21 sec	36	25
SST1/SST2/SST3 (sec)	14.25/13.28/11.65 sec	8.41/7.56/8.12	8.53/8.2/8.3

Satisfaction score: 38/50; I did not get significant computer related headaches during the 2-week wear.

The following ocular tests were administered to evaluate visual function at baseline and with the SV and MF contact lenses. Visual acuity, EOM, pupil size, NPC, vergence amplitude, phorias, NRA/PRA, accommodative and vergence facility, stereoacuity (Super Stereo Test), and tear break up time were measured at distance and near as appropriate. Contact lens fitting and education was provided to all subjects prior to dispensing. Subjects were initially randomized to either Proclear Sphere SV contact lenses or Proclear EP Multifocal contact lenses for the first two weeks, then crossed-over for two weeks of wear with the other lenses.

Results

Five subjects (ages 31, 30, 24, 24, and 28 years) were enrolled in the study and are presented sequentially as a case series. Comprehensive eye examination of all subjects revealed normal ocular health with the exception of visual discomfort symptoms. Case #3 and Case #4 were habitual single vision contact lens wearers prior to the study.

Case 1:

The first subject was a 31-year-old Caucasian male with a history of five separate TBI events. Three were caused by mountain bike accidents, one was from a soccer accident, and one was from a car accident. He reportedly lost consciousness twice, once following a bike accident and again after the car accident. Emergency room doctors evaluated him after each incident. He has had four different CT scans plus an MRI scan related to his accidents. All of his medical evaluations were described as normal, despite his persistent headaches and eyestrain complaints particularly after reading. As can be seen in Table 1, baseline visual performance data indicates moderate CISS symptomology level, low refractive error, mildly reduced NPC, and significantly reduced near vergence recoveries for positive fusional convergence (PFC) and negative fusional convergence (NFC).

With the SV treatment lenses, subject #1's CISS score was moderately reduced, but dramatically improved with MF lenses. With multifocals, NPC was improved and the NRA value trended towards improvement, but NFC and PFC recoveries did not.

Table 2: Visual function data for case #2

Procedure	Baseline	Single Vision	Multifocal EP
Visual Acuity	17	18	18
Contact Lens Rx	-0.25, -0.25	-0.25, -0.25	-0.25, -0.25
CISS	14	12	20
Cover test (D/N)	0/0	0/0	0/0
NPC	8/14	8/12	6/11
Vergence Supra (D)	(Br/R) 3/1	3/1	3/1
Vergence Infra (D)	(Br/R) 3/1	3/1	3/1
Divergence (D)	(Bl/Br/R) 6/6/2	6/6/2	6/6/4
Convergence (D)	(Bl/Br/R) 8/8/2	9/9/4	8/8/6
Vergence Supra (N)	(Br/R) 3/1	3/1	3/1
Vergence Infra (N)	(Br/R) 3/1	3/1	3/1
Divergence (N)	(Bl/Br/R) 6/12/6	10/12/6	10/12/8
Convergence (N)	(Bl/Br/R) 12/12/-2	6/12/2	6/16/2
NRA	(Br/R) 1/1	1/0.5	0.75/0.75
PRA	(Br/R) -2.25/-1.50	-0.75/-0.50	-2.25/-1.5
Accom Fac (+/- 1.5D)	(10cyc) 56.25	54.53	58.8
Vergence Fac (8BI)	38.15 sec	35.36	45.84
Vergence Fac (8BO)	35.37 sec	36.13	29.12
SST1/SST2/SST3	22/17.9/26.65	10.72/9.84/20.94	11.88/8.41/17.38

Satisfaction score: 47/50; The lenses did not have any effect on my visual symptoms.

Based on the interview and a lens satisfaction survey, he reported that the SV contact lenses did not change his symptoms nearly as much as the multifocal lenses. He indicated enhanced visual comfort and diminished headaches from the MF lenses. He described the MF relief to be similar to wearing his +1.00 reading spectacles which he had been using for his school work for years to manage his visual discomfort. Overall, subject #1 was happy enough with his study multifocal experience to order MF contact lenses for himself as another option to relieve his near-task related visual discomfort following the study.

Case 2:

A 30-year-old Caucasian female experienced three car accidents between 2007 and 2009. She had three MRIs, each of which was unremarkable, but she continued to suffer from headaches and photophobia. To help her function, she had to turn fluorescent lights off while working, which was not the case before the car accidents. Currently, she is on a medication for migraine headaches plus some muscle relaxants. Her binocular vision data are presented in Table 2. Baseline visual performance data indicates a subclinical CISS symptomology level, low refractive error, mildly reduced NPC, poor convergence amplitude at distance, significantly reduced PFC and NFC, and deficient PRA and NRA at near.

Based upon subject #2's interview and contact lens satisfaction survey, she was comfortable wearing the contact lenses during the day but did not like the associated MF blurriness and did not feel that they provided relief from her other visual symptoms. With the MF contact lenses her NPC was better and her stereoacuity response times were measured as quicker. Neither SV nor MF improved her baseline PFC, NFC, NRA, or PRA. Curiously, her CISS score increased to nearly the clinically significant level with the MF lenses, suggesting increased visual discomfort with the MF treatment.

Case 3:

A 24-year-old Asian female suffered a concussion from a snowboarding crash in 2007, but she did not go the emergency room. She still experiences headaches once a week and feels nauseous in the car. Her data are shown in Table 3. Baseline data show moderate myopia, deficient NFC and PFC recoveries, and clinically significant CISS symptom severity.

She was a habitual single vision contact lens wearer prior to the study. Based on her interview and the contact lens satisfaction survey, she did not like either the SV or MF study contact lenses because she didn't think they fit her well and her vision fluctuated due to excessive movement. Nevertheless, she was able successfully to wear both the SV and MF treatment lenses for the duration of the study.

Both the SV and MF lenses reduced her CISS score, but not below the threshold level considered clinically insignificant. NFC and PFC did not improve, and PRA was worsened. Although accommodative facility was better with the MF lenses, vergence facility was poorer.

Table 3: Visual function data for case # 3

Procedure	Baseline	Single Vision	Multifocal EP
Visual Acuity	17	18	18
Contact Lens Rx	-3.25, -4.00	-3.25, -4.00	-3.25, -4.00
CISS	41	25	28
Cover test (D/N)	0/0	0/0	0/0
NPC	0/0	0/0	0/0
Vergence Supra (D)	(Br/R) 4/1	3/1	3/1
Vergence Infra (D)	(Br/R) 4/1	3/1	3/1
Divergence (D)	(Bl/Br/R) 10/12/4	10/10/4	8/10/6
Convergence (D)	(Bl/Br/R) 16/16/8	14/14/6	10/12/6
Vergence Supra (N)	(Br/R) 5/2	5/2	5/2
Vergence Infra (N)	(Br/R) 5/1	4/1	5/2
Divergence (N)	(Bl/Br/R) 8/18/6	6/16/4	10/18/8
Convergence (N)	(Bl/Br/R) 18/20/10	6/6/4	12/12/6
NRA	(Br/R) 2.25/2	2.75/2.5	3/2.5
PRA	(Br/R) -2.00/-2.00	-1.00/-0.75	-1.5/-1.5
Accom Fac (+/- 1.5D)	(10cyc) 52.03 sec	44	41.94
Vergence Fac (8BI)	38.88 sec	74	125
Vergence Fac (8BO)	30.87 sec	27.72	36.66
SST1/SST2/SST3	19.46/12.5/26.54	14.71/13.87/16.59	14.06/10.84/19.85

Satisfaction score = 35/50; The lenses were quite uncomfortable at the end of the day.

Table 4: Visual function data for case # 4

Procedure	Baseline	Single Vision	Multifocal EP
Visual Acuity	17	22	20
Contact Lens Rx	-6.25, -6.25	-6.25, -6.25	-6.25, -6.25
CISS	37	25	25
Cover test (D/N)	0/4EP	0/4EP	0/4EP
NPC	0/0	0/0	0/0
Vergence Supra (D)	(Br/R) 3/1	3/1	4/1
Vergence Infra (D)	(Br/R) 4/1	3/1	4/1
Divergence (D)	(Bl/Br/R) 8/8/12	16/16/8	12/12/7
Convergence (D)	(Bl/Br/R) 30/30/14	32/32/14	32/32/14
Vergence Supra (N)	(Br/R) 5/2	4/1	5/2
Vergence Infra (N)	(Br/R) 5/2	4/1	5/2
Divergence (N)	(Bl/Br/R) 26/26/18	18/18/10	24/24/14
Convergence (N)	(Bl/Br/R) 32/32/33	28/32/24	32/32/24
NRA	(Br/R) 2.25/2.25	2.75/2.25	2.75/2.25
PRA	(Br/R) -3.50/-3.25	-3.50/-3.25	-2.5/-2.0
Accom Fac (+/- 1.5D)	(10cyc) 38.47 sec	38.47	36.91
Vergence Fac (8BI)	30.78 sec	29.06	31.63
Vergence Fac (8BO)	29 sec	27.96	28.50
SST1/SST2/SST3	13.12/7.28/13.37	7.03/7.84/12.88	8.43/12.88/9.81

Satisfaction score = 32/50; The lenses were moving a lot in my eyes.

Case 4:

A 24-year-old Caucasian female experienced a concussion from a ski accident five years ago. She went to the emergency room after the incident, but no imaging was performed. She still gets intermittent headaches at the end of the day. Her data is summarized in Table 4. She presented with borderline high myopia, esophoria at near, and a significant CISS score.

Table 5: Visual function data for case # 5

Procedure	Baseline	Single Vision	Multifocal EP
Visual Acuity	16	17	16
Contact Lens Rx	-3.50, -4.00	-3.50, -4.00	-3.50, -4.00
CISS	32	29	23
Cover test (D/N)	0/0	0/2EP	0/2XP
NPC	0/0	0/0	0/0
Vergence Supra (D)	(Br/R) 2/1	2/0	2/1
Vergence Infra (D)	(Br/R) 3/2	3/2	2/1
Divergence (D)	(Bl/Br/R) 8/8/6	6/6/2	16/16/4
Convergence (D)	(Bl/Br/R) 12/12/10	18/34/16	8/34/28
Vergence Supra (N)	(Br/R)2/1	3/2	2/1
Vergence Infra (N)	(Br/R) 4/3	3/2	3/0
Divergence (N)	(Bl/Br/R) 14/22/13	7/25/12	10/23/18
Convergence (N)	(Bl/Br/R) 13/14/30	12/34/38	18/14/28
NRA	(Br/R) 1.50/1.25	2/1.75	3/2.5
PRA	(Br/R) -6.00/-5.75	-4.75/-4.25	-4.75/-4.50
Accom Fac (+/- 2.00D)	(1 min) 12 cyc	8 cyc	15
Vergence Fac (8BI)	(2 min) 11 cyc	12	17
Vergence Fac (8BO)	(2min) 9 cyc	17	30
SST1/SST2/SST3	25/20/20	25/20/20	20/25/20

Satisfaction score: 47/50; I have less diplopia and headache at near with multifocal contact lens.

Her baseline visual performance measures were normal with the exception of near esophoria.

She was also a habitual single vision contact lens wearer. Based on her contact lens interview and satisfaction survey, she did not appreciate the effects of the MF treatment contact lenses because of excessive lens movement and the moderate amount of under-corrected astigmatism in her left eye (-6.50-1.25x003). Post-study, she continues to wear her habitual contact lenses as her primary correction for her daily visual needs.

With treatment lenses, there were no substantial differences in her binocular test performance as compared to baseline. The one exception was a poorer PRA with the MF lenses.

Case 5:

A 28-year-old Caucasian female suffered a closed-head injury from a mountain biking accident in July 2008. She was brought to the emergency room and then transferred to a larger hospital where she stayed for 10 days. The diagnosis was concussion and sub-arachnoid hemorrhage. She has found that since her head trauma she cannot read as much as she used to, especially when she is tired. She gets double vision and has a hard time comprehending what she reads. Her doctor mentioned that her left eye still had remnants of bone fracture in the socket. Her binocular data is presented in Table 5. Her baseline findings indicated moderate myopia, vertical vergence asymmetry at near and far, reduced NRA, low distance convergence break, deficient near divergence recovery, and a moderately high CISS score.

Based on subject #5's interview and lens satisfaction survey, she was more comfortable and had less diplopia and headache at near with the MF treatment lenses. She reported improvement despite some periodic dryness and blurriness while wearing the MF contact lenses. Post-study, she decided to order MF contact lenses and has been using them for school and for her studying needs.

With the MF treatment lenses, subject #5 demonstrated less visual discomfort. Her CISS score improved with the multifocals to nearly the subclinical threshold level. Relative to baseline, many near binocular performance measures showed improvement with the MF lenses. Orthophoria changed to low exophoria, NRA was normalized, and accommodative and vergence facilities were better. Almost no improvement was measured with the SV lenses.

Discussion

To the best of our knowledge, this pilot study with a small sample of mTBI cases is the first systematically to measure baseline visual comfort and performance and compare it to single vision and multifocal contact lens correction. The CISS questionnaire was used as the main outcome measure to gauge visual discomfort symptoms. Binocular tests were done to assess the visual performance with and without contact lens

correction. Interview and satisfaction surveys were used to understand the effectiveness of single vision and multifocal contact lenses for the relief of visual discomfort.

The first hypothesis to be tested was whether adult patients (between the ages of 24 to 31 years) with a history of mTBI would be able to tolerate contact lenses for sustained wear and daily activities. The second hypothesis was to determine whether the Proclear EP Multifocal lens could be effective in relieving asthenopia (visual discomfort), headache, or intermittent diplopia with pre-presbyopic mTBI subjects. If subjective visual comfort was improved by contact lenses, the contingent third hypothesis was whether the visual performance data would reflect any reported subjective improvement.

The results from this study support the first two hypotheses for some patients. Further study with a larger population is needed to establish patient selection criteria for contact lens treatment; however, all of our mTBI subjects were able to wear contact lenses throughout the day for the duration of the study. Two of five mTBI subjects experienced relief from visual discomfort when wearing multifocal contact lenses. Although a few visual performance tests for these two subjects did improve with the MF contact lenses, the pattern was not easily discernable and was different for each subject.

Asthenopia or eyestrain is frequently a clinical complaint with TBI patients. The challenge for the clinician is to determine the cause(s) of the asthenopia and to implement a treatment plan to ameliorate the symptomatology. Oculomotor dysfunctions are relatively common among the general population, with a range from 20% to 30% found in young adults.[16] It should be noted that they are even more pervasive in the TBI population. A recent retrospective study found that approximately 90% of individuals with mTBI presenting with vision-related symptoms were diagnosed with one or more oculomotor dysfunctions following their acute care phase and natural recovery period.[17] The high prevalence, however, is not so surprising because six out of twelve cranial nerves have direct input to the visual process. Injury to the brain is often widespread, and it is more likely than not that one of those six innervations to the eye is adversely affected. Hence, a wide range of visually related symptoms can arise from TBI incidents. This long list of symptoms can range from glare and excessive light sensitivity to tired eyes, difficulty sustaining focus at near, and intermittent double vision throughout the day.

Previous literature has shown that both accommodation and vergence are adversely disrupted by TBI.[17] Accommodative dysfunctions in mTBI include accommodative insufficiency (AI), most commonly seen in mTBI, accommodative excess (AE) or pseudomyopia, and dynamic accommodative infacility.[8] A number of past studies have estimated that between 10% and 30% of mTBI patients suffer from AI.[18] A logical assumption is that this group of patients is more likely to appreciate a plus addition for near tasks, and thus MF contact lenses could potentially alleviate a near focusing deficit.

Based upon baseline PRA values, only Case #2 from this study would qualify as having AI. The MF treatment lens with additional plus for near did not improve subject #2's deficient PRA value and yielded an even worse CISS score relative to baseline. It should be pointed out that subject #2's visual problems were not limited to accommodation. Her vergence findings at distance and near were deficient, as was her NPC. Subject #2's baseline findings indicated a combined vergence and accommodative problem. On the flip side, subjects #1 and #5 preferred the MF lenses and had improved CISS scores wearing them, but did not demonstrate deficient baseline PRA or dynamic accommodative facility values. It would appear for this small group of subjects, AI alone based upon PRA was not predictive of MF preference or reduction of CISS score.

Vergence system abnormality was found in more than half of an mTBI sample in a recent study.[17] Convergence insufficiency was the main vergence dysfunction, accounting for 42.5% of the total. However, convergence excess, basic exo-deviation, and divergence insufficiency were also noted.

Each of our five study subjects exhibited some degree of baseline vergence dysfunction. With vergence dysfunction, the expected subtypes most likely to benefit from additional near plus would be those with convergence excess/esophoria, particularly those coupled with subnormal divergence amplitude. Subject #5, who preferred the MF treatment lenses and had fewer symptoms with them, would fall into that category. With the MF lenses, subject #5's relative near esophoria shifted to low exophoria, and near base-in vergence recovery, vergence facility, and NRA improved. Subject #1, who also preferred the MF treatment lenses and had fewer symptoms with them, did not demonstrate improved near base-in vergence recovery with the additional near plus from the MF lenses. NPC did however improve.

Even though subject #4's symptoms were diminished somewhat, her baseline near esophoria did not improve with the MF lenses. Because her PRA actually worsened, it is conceivable that she was not a short-term responder to the additional plus at near provided by the MF lenses. An alternative explanation for her non-responsiveness was the significant uncorrected astigmatism in her left eye. She was very conscious of the lens movement and blurriness. She would have preferred a toric lens, but Proclear EP is available only with spherical correction.

Subject #3 presented with a mild baseline vergence dysfunction. Both base-in and base-out recovery amplitude was below normal. MF near plus improved accommodative facility and CISS symptoms a bit but worsened PRA and vergence facility. She did not appreciate the contact lenses because she felt excessive movement, even though the fitting was judged as an acceptable to good fit. It is also possible that her blur complaint stemmed more from the complex multifocal optics rather than the added plus. This was a more challenging case to manage so she was referred to vision therapy.

Other oculomotor dysfunctions, although less frequent, have also been diagnosed following TBI. These include strabismus and third and fourth cranial nerve palsies.[17] Vertical vergence imbalances have also been reported to be common with mTBI subjects.[17] Baseline test measures for subject #5 suggested vertical oculomotor imbalance at near, while subject #3 demonstrated this tendency at near only. Obviously, soft lens prism correction/compensation for vertical imbalance is not currently available in MF lenses so if the vertical muscle imbalance were the primary source of visual discomfort, one would not expect elimination of asthenopia with the study treatment lenses. These cases are probably more amenable to vision therapy or prism prescription. From our limited data set we cannot determine whether the vertical imbalances were pre-existing and to what degree the subjects had adapted. Curiously, both subjects had a reduction in their CISS scores with our treatment lenses, suggesting that multiple factors may have been contributing to the reported visual discomfort. In summary, it is quite possible that all the subjects in this study suffer from a combination of different oculomotor dysfunctions rather than a single binocular disorder, since mechanisms of oculomotor function are likely interconnected and interdependent.

Study limitations include a small sample size and lack of medical case history records to corroborate the self-reported brain injuries. However, each subject demonstrated a clear recollection of his/her brain injury(s). Further, only one type of MF contact lens was used in the study, and we were not able to provide optimal fitting for all our subjects. It is important to note that while only the Proclear EP Multifocal, a center-near design, was chosen for this study because the lens was designed for early presbyopia and patients with possible dry eye syndrome, many different multifocal lens designs and parameters are currently available. For instance, Acuvue Oasys for Presbyopia (Vistakon) is a two-week replacement, center-distance lens that can be ideal for emerging presbyopes, because it provides sharp distance vision and minimizes unwanted visual symptoms even with larger pupils in dim light. The center-near design may compromise the distance vision in bright light when the pupils constrict, whereas the center-distance design may not have this problem, but it may not provide enough plus when the pupils are small. The keys to success in fitting MF contact lenses start with good measurements and appropriate selection of lenses. These include tear film assessment, ocular dominance, binocular refraction in light and dim setting, and use of fitting guides from manufacturers.[19] Recently, for example, Cooper Vision launched the Proclear 1-day multifocal lens. This option could potentially prove to be a convenient modality for some mTBI patients. Follow up research is needed to determine whether a larger proportion of mTBI patients could benefit from successfully fitted multifocal contact lenses.

Another limitation is that the primary instrument used to determine symptoms in this study (CISS) was designed for visual symptoms characteristic of convergence insufficiency rather than brain injury. Availability of a valid and reliable brain injury visual symptom survey would have been beneficial.

Conclusions

More people are living with the long-term effects of TBI than ever before because of advances in medical care. Many struggle with the long-term visual consequences of mTBI. Common lingering effects of TBI are complex patterns of difficult-to-manage visual discomfort, presumably related to oculomotor dysfunction. Vergence, accommodation, and extraocular motility can be affected in isolation or in combination. Most eye care professionals face the daunting task of determining how best to manage these complex cases. Multiple treatment modalities may be necessary to alleviate chronic visual discomfort secondary to TBI. Spectacle lens correction, prism, spectral tints, and vision therapy treatments are often used alone or in combination to manage TBI patients. Based upon our preliminary results, multifocal contact lenses should also be considered as a potentially beneficial modality for select TBI patients. It also suggests avenues for potential future intra-disciplinary opportunities for binocular vision specialists to collaborate with contact lens specialists.

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