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Oculomotor diagnostic protocol for the mTBI population

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There is an ever-increasing awareness and visibility of the medical condition traumatic brain injury (TBI) in the United States. This is especially true in light of recent military conflicts[1] and professional football league probes of players' concussions.[2] However, despite such heightened sensitivity to this serious and pervasive problem, in particular with regard to the diagnosis of the many associated visual sequelae, there remains hesitation and a degree of uncertainty related to many aspects of its visual diagnosis and hence its subsequent treatment and remediation. For example, there is uncertainty and lack of clarity regarding what constitutes an optimal visual oculomotor diagnostic test protocol.

We receive queries on a weekly basis requesting assistance with the visually related aspects of TBI, in particular the "mild" form (mTBI). These requests for guidance come from Veteran's Affairs (VA) hospitals, medical practices, occupational therapists, and some optometric practices. Most of those requesting guidance and assistance perceive mTBI patients, with their constellation of related vision and non-vision dysfunctions, to represent something very "different," "special," and even a bit "perplexing," when compared to the typical patient having a basic oculomotor dysfunction (OMD; ICD-9-CM: 794.14) and/or accommodative insufficiency (AI; ICD-9-CM: 376.5) in the absence of any other medical condition. Those who inquire are often stymied and do not know where to start with these patients. Furthermore, some of these clinical conceptualizations have been veiled in language and related concepts that have perplexed and confused the novice and even the seasoned optometric practitioner. For the most part, this is a misperception.

As previously mentioned, mTBI does create a constellation of basic vision, oculomotor, and related problems[3] (*see* Table 1). However, given the fact that 3 of the 12 cranial nerves (CN) deal directly with fine oculomotor control (CN III, IV, and VI) and a fourth (CN VIII) deals with the vestibular system and its interactions with vision (e.g., vision vestibular neuromotor interactions related to both the versional and vergence systems), it is not surprising that oculomotor problems are prominent. For example, convergence insufficiency,[4] accommodative insufficiency,[4] and saccadic dysmetria (i.e., saccadic inaccuracy)[5,6] are the most frequent oculomotor deficits found in the visually symptomatic mTBI clinic population, with 90% having a diagnosed oculomotor dysfunction.[4] These are the same oculomotor deficiencies/diagnoses found in the typical, non-mTBI, OMD and/or deficient accommodation patient.[7,8]

Given this information, we have a "model" of this patient. We think of the mTBI patient as having 3 levels of problems. First, we conceptualize the mTBI patient as having the same, or at least similar, oculomotor deficits as OMD, typically with an accommodative component that can be readily remediated with conventional optometric vision therapy.[8,9] Second, they are perceived to be more complicated because of the "overlay" of other problems related to the mTBI in general. These include poor attention, short-term memory lapses, behavioral problems, and general/ocular fatigue, to name a few.[3,6] Medications may have undesirable side effects as well.[10] Third, there are other vision-related conditions that may make these patients appear to be more challenging, but they too can be remediated using one's basic optometric armamentarium. These additional visual conditions may include photosensitivity,[11,12] motion sensitivity,[13] vestibular dysfunctions,[14] visual field defects,[15] and spatial mislocalization.[16] However, these can be easily and effectively managed using tints,[3] binasal occlusion,[3] vestibular training,[6,14] field-enhancing prisms,[15] and yoked prisms,[16,17] respectively. These concurrent issues

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Table 1 Oculomotor and visual symptoms in a mild tramatic brain injury (adapted from Ciuffreda et al., 2009)

- Oculomotor-based reading difficulties *(the most common symptom)*
- Eye-tracking problems
- Difficulty with global scanning
- Eye-focusing problems
- Avoidance of near tasks
- Eye strain
- Diplopia
- Dizziness
- Vertigo
- Vision-derived nausea
- Increased sensitivity to visual motion
- Photosensitivity
- Visual inattention and distractibility
- Short-term visual memory loss
- Difficulty judging distances (relative and absolute)
- Inability to interact/cope visually in a complex social situation (e.g., minimal eye contact)
- Inability to tolerate complex visual environments (e.g., grocery store aisles, crowds, and highly patterned floors)

can indeed make patient management more difficult, but still quite doable.

Thus, based on our recent studies on vergence[18,19] and accommodation,[20,21] as well as our earlier research on version and reading,[5,22] we propose the following parameters to be diagnostically important in each area to be tested in the mTBI population (*see* Table 2). These clinic oculomotor and accommodative parameters were found to be present with a very high frequency of occurrence in this population. Thus, they will result in the highest yield (i.e., few false positives) and be of greatest clinical predictive value. In addition, when available, the objectively based and automated Visagraph eye movement recording system[23] should be used to assess reading ability and visual efficiency, as reading difficulty is the most common symptom in the mTBI population (*see* Table 1).[4,24-26]

Table 2 Targeted clinical oculomotor parameters

Vergence
- NPC break (especially with repetition)
- NPC recovery (especially with repetition)
- PRV break
- PRV recovery
- Vergence facility (prism flipper baseline)
- Vergence facility (prism flipper fatigue)
- Horizontal near dissociated phoria
- AC/A ratio
- Fixation disparity at near
- Associated phoria at near
- Stereoacuity (per its relation to vergence error)

Accommodation
- Accommodative amplitude
- Accommodative facility (lens flipper fatigue)
- PRA/NRA

Version
- Fixational stability
- Saccadic accuracy
- Pursuit accuracy
- DEM

NPC = near point of convergence; PRV = positive relative vergence; AC/A = accommodative convergence to accommodation ratio; PRA = positive relative accommodation; NRA = negative relative accommodation; DEM = Developmental Eye Movement test.

With the above proposed diagnostic protocol, and related OMD and AI categorizations, the next critical step can be taken, namely therapeutic intervention (e.g., optometric vision therapy).[8,9] The targeted diagnostic test battery should also serve to guide intervention with respect to those oculomotor and accommodative aspects exhibiting the most deficiency. This therapy has been well documented in the literature using both objective recording techniques to assess oculomotor and accommodative system responsivity following therapeutic intervention[9] and more formal clinical trials.[27]

In conclusion, we have presented a clear and simple perspective with respect to vision management for the mTBI population. This includes a targeted and comprehensive oculomotor and accommodative diagnostic clinical test protocol. For the most part, the patient should not be approached as "special," but rather simply a more challenging and extreme case of OMD and AI for the contemporary, full-scope optometrist.

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