“Light on the Pupil and Concussion: A Perspective”

Kenneth J. Ciuffreda, OD, PhD, FCVD-A, FAAO, FARVO
Nabin R. Joshi, B. Optom.

“Some believe that the pupil is the window to the soul. The pupil may also be the window to concussion/mild traumatic brain injury (mTBI).”

The investigation of vision problems and related vision deficits in the concussed/mild traumatic brain injury (mTBI) population has become a central focus of many neuro-optometrists, and others, over the past decade or so. The impetus has been the reported high prevalence of mTBI related to the recent war efforts in the Middle-East and to sport concussions, as well as the heightened attention this topic has received in the press, governmental agencies, and the medical community.

However, an accurate and definitive diagnosis of concussion, especially at the acute phase, may not be so simple, as the symptoms are vague at times and subjective in nature. For example, a coach or parent may ask the young athlete, “How do you feel?” or “Are you OK?”, after sustaining a blow to the head and neck region, or even to the entire body. The athlete may not wish to either disappoint or worry the coach or parent, respectively, so the response might be, “Fine.” But, is this really true? In some cases, it may not. Assuming a concussion has actually occurred, returning the athlete to the playing field prematurely may set the stage for another possible concussion, especially if the player is still slightly “stunned” or “out of it” attentionally.

Two oculomotor-based approaches have been suggested for the assessment of acute concussion on the sports field. They may also be applicable to the military theater. The first is the testing of saccadic eye movements involving a global visual search paradigm. For this, the King-Devick test has received much attention for use in a range of sports. This test is subjective and volitional in nature, with a relatively strong cognitive component, and thus may be subject to variability and interpretation. The same is true for the Developmental Eye Movement (DEM) Test.

The second approach is automated saccadometry, which also involves saccadic eye movements, but incorporates an objective assessment and quantification for the parameter of saccadic latency. This procedure also has a strong volitional and attentional aspect, although it has a low cognitive demand.

An alternative approach is the objective assessment of pupillary dynamics through automated pupillometry. This may be particularly useful in the acute sideline sports case of a player having a possible concussion. The testing is not subjective, and furthermore does not have a volitional, attentional, or cognitive component that may adversely influence or bias the findings. It is a simple, reflexive response. We, and others, have used this approach...
to assess the pupillary light reflex (PLR) in this general population, with considerable success. A schematic representation of the dynamic pupillary response to light and the test conditions are presented in Figure 1. Several potential, objective, pupillary-based, vision biomarkers for concussion/mTBI with a high diagnostic impact have been identified, none of which can be detected and differentiated from normal using standard penlight clinical testing of the PLR. Some of these newly uncovered, key pupillary parameters include peak constriction velocity and peak dilation velocity, as well as others, using a bright, white light step test stimulus (Table 1). And, with a bright red step stimulus, two additional parameters were found to be likely biomarkers: constriction latency and peak constriction velocity. Testing is rapid (a few seconds per eye), non-invasive, easy to implement, automated, quantitative, and easily interpreted when compared to normative data (Figure 2). Thus, the tentative diagnosis of concussion, and mTBI in general, may be immediate and beyond dispute in many cases. Lastly, this test could be also used for disability assessment.

**Figure 1:** A schematic representation of the dynamic pupillary response to light and the various test conditions

**Table 1. Potential Objectively-based Pupillary Biomarkers for Concussion/Mild Traumatic Brain Injury for a Bright White Step Stimulus**

- peak dilation velocity
- average dilation velocity
- average constriction velocity
- maximum pre-stimulus pupil diameter
- minimum post-stimulus pupil diameter
- pupil diameter 6 seconds post-stimulus
Future investigations will be required in several targeted cohorts (e.g., young children and young adults in sports, those in the military theater, patients in the emergency room) to determine if this prediction is fulfilled and eventually becomes a reality.

REFERENCES


