NEUROLOGICAL VISION SCREENING AFTER TBI CLINICAL PRACTICE GUIDELINE

The following are recommendations for a thorough screening of neurological vision impairment, based on the current scientific literature, which can then be used to develop a client-centered treatment plan, in collaboration with an OD or MD (vision specialist). A visual screener can be completed by a trained, non-vision specialist clinician, but it does not substitute for a full evaluation by a vision specialist. It allows us to identify appropriate candidates, make needed referrals, and opens up the line of communication between the therapist and vision specialist. It is not within an OT's scope of practice to diagnose. Many conditions can be treated by a licensed therapist who has been trained in vision therapy techniques, but must be in collaboration with a vision specialist. This collaboration allows integration of assessments of the eye/lower-order cerebral mechanisms (visual function) and person-level dysfunction/higher-order cerebral mechanisms (functional vision), targeting quality of life. [37] The ideal setting for providing the patient with brain injury with appropriate vision care and therapy is a team of providers working together in a vision clinic.[36]

Vision Specialists

- Optometrist – Doctors of Optometry (OD) diagnose and treat vision problems, eye diseases and related conditions, prescribe eyeglasses and contact lenses and provide medication to treat eye disorders. They cannot perform surgery but often provide pre and post-surgical care.
  - ***It is important to refer neuro/concussion patients to an Optometrist who can provide a neuro-optometric/sensorimotor evaluation, as not all Optometrists perform this type of assessment. (See specialists on page 10).**

- Ophthalmologist – MD who specializes in the medical and surgical care of the eyes and visual system and in the prevention of eye disease and illness.

- Neuro Ophthalmologist – Subspecialists of neurology and ophthalmology who address visual problems related to the nervous system.

    www.aoa.org

    http://www.eyesitemd.com/ophthalmologist.htm

    www.nora.cc

    covd.org

Terminology

The 3 subsystems of version, vergence and accommodation must be precisely synchronized for efficient oculomotor control during activities such as reading.

Accommodation	The ability of the eye to change focus from distance to near objects, and is achieved by the ciliary muscle adjusting the shape of the intraocular lens. It occurs reflexively with convergence. Accommodative dysfunction may result in Accommodative Insufficiency, Spasm (overstimulation), or Infacility (slowed)
Vergence Eye Movements	The simultaneous movement of both eyes, in opposite directions, as needed for single, binocular vision, and stereopsis. 1st degree fusion is the appreciation of a double image, 2nd degree fusion is the appreciation of some overlap between the two images, and 3rd degree fusion is single vision and stereopsis. Stereopsis is binocular depth perception, as the two separate images from each eye are successfully combined /fused into one image in the brain. Vergence eye movements include *con*vergence and *di*vergence.

Binocular Vision Disorders	**Strabismic** - eyes are misaligned, may be constant or intermittent • Esotropia – eyes turn in • Exotropia – eyes turn out • Hyper tropia – one eye turns up • Hypotropia - one eye turns down	**Non-strabismic** • Esophoria – eyes have a *tendency* to turn in • Exophoria – eyes have a *tendency* to turn out • Hyperphoria – one eye has a *tendency* to turn up • Hypophoria – one eye has a *tendency* to turn down

Diplopia	Double vision that suggests misalignment of the eyes. Occurs when the object at which the individual is looking stimulates the fovea (part of the retina that contains the area of most acute vision) of one eye, and a non-foveal part of the retina of the other eye.
Suppression	A condition in which the visual system ignores the input from one eye, usually associated with strabismus or amblyopia.

Versional Eye Movements	Saccades - fast, simultaneous eye movements in the same direction, to change the fixation point. During visual scanning, as in reading, the eyes make saccadic movements and stop several times, moving very quickly between each stop. Saccadic dysfunction may include impaired velocity, accuracy, and or initiation of eye movements (ocular motor apraxia). While undershooting is not unusual, overshooting is.	Pursuits - eye movements that allow smooth, continuous viewing of a moving object, and play a significant role in driving and sports. Pursuit dysfunction can include ataxia (jerky quality), and decreased velocity.

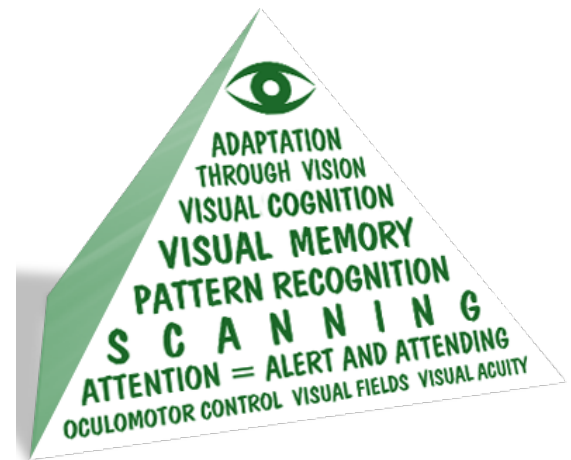|	
Peripheral/ Ambient Vision	Allows awareness of position in space, and provides general information needed for balance, movement, coordination, and posture. Unstable ambient vision after BI may cause vertigo, sensitivity to light and motion, and nausea. Also, having intact visual fields does not necessarily correlate with intact peripheral awareness or intact central/peripheral vision integration.
Vestibulo-Ocular reflex (VOR)	The VOR is one of the fastest reflexes in the human body. At least slight head movement is present all of the time, so the VOR is always important for gaze stabilization. Reflexive eye movements stabilize images on the retina during head movement by producing a compensatory eye movement in the direction opposite to the head movement. In order to have clear vision, head movements must be compensated for almost immediately. Individuals with VOR impairment may complain of vision "looking like a photograph taken with a shaky hand", or seeing "trails", dizziness, and imbalance.

Background

Subtle changes in brain function can occur even after mild TBI/Concussion. Approximately 80% of our perception, learning, cognition and activities are mediated through vision,[23] and greater than half of the circuits in the brain are involved in vision[3, 53], including many regions susceptible to shearing during head impacts. Visual system tests probe higher cortical functioning, and assist in detecting functional changes in patients. Abnormal oculomotor and binocular vision skills (ie convergence, accommodation, ocular muscle balance, saccades, and pursuits), vestibular-ocular reflex, and subjective visual complaints are common following TBI, including mTBI [3,18,19,48,49]. Oculomotor dysfunction has been estimated to be as high as 90% in individuals with TBI, followed by accommodative and convergence deficits [37,47]. Further, early detection of vision abnormalities may predict individuals at risk of more severe head impacts [49]. Also, it is worth noting that approximately 95% of patients with visual symptoms/complaints caused by TBIs have normal fundoscopic (exam of the retina) findings. An individual can have normal acuity (ie 20/20), but still have impaired oculomotor or eye teaming skills, and therefore impaired functional vision. Also, vision disturbances may be overlooked due to a patient's difficulty in verbally describing impairments.[3]

Poorer oculomotor function is correlated with more post-concussive symptom s and problems with ADL [21,48]. Likewise, a recent study by [32], found that Convergence Insufficiency was common (~42%) in athletes evaluated within 1 month after a sport-related concussion, and that these athletes had worse neurocognitive impairment and higher symptom scores than did those with normal NPC [32]. In such cases, more effort will constantly be required for the individual to perform these lower-level actions (ie basic oculomotor control to focus/fuse words) which should be automatic. Subsequently, higher level skills such as comprehension, attention, short-term visual memory, and executive function, will be compromised.[32, 46] The concept of visual skill hierarchy is illustrated by the Mary Warren Triangle [50]:

Incidence

Common visual impairments in first year post-TBI[17]	• Blurred vision • Difficulty with reading • Diplopia/eye strain • Dizziness or disequilibrium in visually crowded environments	• Visual field impairments • Photosensitivity • Color blindness
Incidence specific to mTBI[17,30,48]	High prevalence in abnormalities of: • Saccades • Pursuits • Vergence (most likely *con*vergence)	• Accommodation • Vestibulo-ocular reflex (VOR) • Photosensitivity

Recommendations

(Radomski, 2014). A consensus panel of experts using a nominal group technique has recommended the screening items below. These items have also been confirmed by Fox, et al., 2019[53], and have been proposed as "better practice" for vision screening post-TBI with adults, until a validated option becomes available for non-vision specialist clinicians. Items are to be performed in this order.[35] *Assessments in italics can also be considered.*

Direct Observation	• Direct observation of occupational performance, with attention to behaviors suggesting vision dysfunction. • Also, consider possible time-dependency of symptoms, as they may not manifest immediately. The individual may report complaints only after performing a visual task for certain duration of time.
Questionnaires/ Surveys	Often, patients have difficulty describing their symptoms, and may not recognize them as related to visual deficits (i.e. fatigue, poor attention, dizziness, headache). Using one or more of the following self-report surveys can help the clinician obtain informative answers.[3] • BIVSS (Brain Injury Vision Symptom Survey)[53, 54] (available at http://links.lww.com/OPX/A248) • COVD QOL outcomes assessment plus photosensitivity interview question [12,35] • *CISS – score of >21 can indicate impairment [38]* • *Goodrich, et al. history questions[19]* • *The Visual Interview [3]* **Questionnaires if Vestibular Impairment is Suspected** • *The Vestibular Disorders Activities of Daily Living Scale[10]* • *The Vestibular Activities and Participation Measure[2,29]*
Far Acuity	• Chronister Portable Acuity Test [35,43] (www.guldenophthalmics.com) • *Snellen Acuity Chart* Referral to OD is necessary if vision is 20/40 or worse. The numerator refers to the testing distance at which the person recognizes the letter, and the denominator refers to the distance at which the letter being viewed could be identified by a person with normal (20/20) visual acuity.[43]
Near Acuity/Reading	• Chronister Portable Acuity Test reading card[35,43] Referral to OD is necessary if vision is 20/40 or worse

*Accommodation**	• Accommodative amplitude testing [43]
	  1. Patch L eye
	  2. Hold a target (ie, fixation stick) with a 20/30 letter about 1 inch in front of the R eye (it will be blurry at this distance)
	  3. Slowly move the target away, and ask the patient to report as soon as he or she can identify the target letter
	  4. Using a ruler, measure the distance from the eye to the target at which the patient was able to identify the letter. Record this measurement in inches
	  5. Divide 40 by the measurement to determine the amplitude of accommodation. The amplitude should be within 2Diopters of the expected finding (see Addendum A for expected amplitude by age).
	  6. Patch R eye and repeat.

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Recommendations (continued)
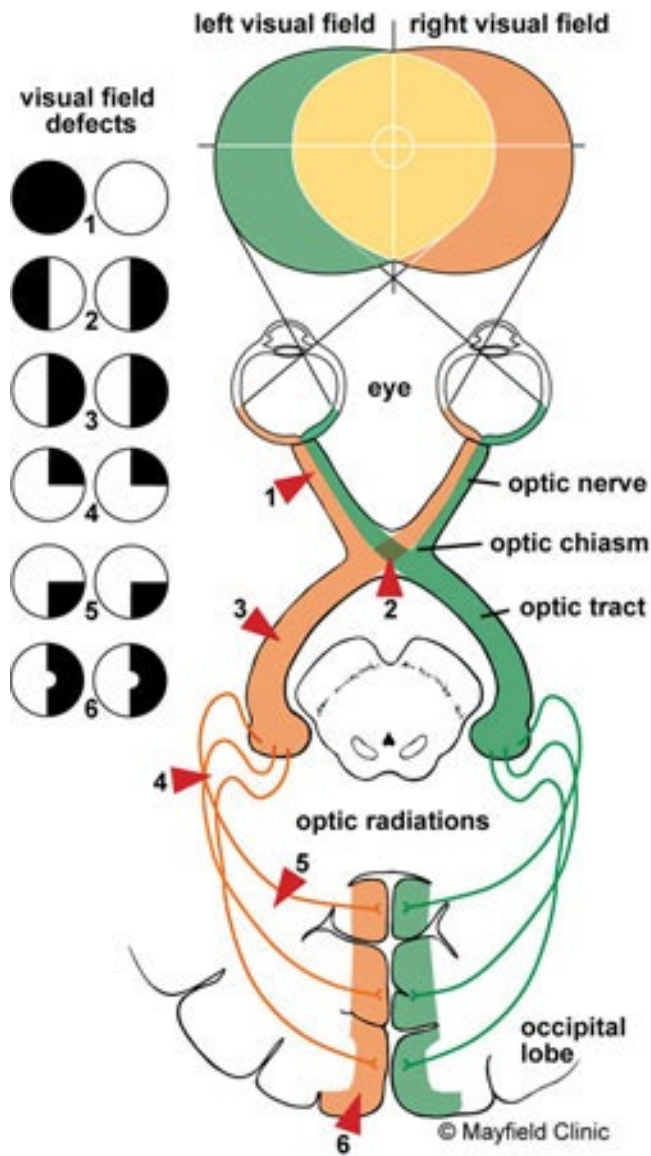

Motor Fusion Testing/Eye Alignment Testing*	• Near Point of Convergence [35,40]
	  1. Use a 20/30 letter target, or pencil tip, placed just above the nose at the brow between the eyes
	  2. Move the target toward the patient at a rate of about 1-2cm/s, encouraging pt to keep the target single
	  3. Measure the patient's reported subjective break (target becomes double) in centimeters
	  4. Then slowly move the target away from the eyes until reported subjective recovery (single again). Measure in centimeters.
	  5. If the pt does not report diplopia (doubling of the target), the point at which the eyes are observed to lose alignment, and then regain alignment, are recorded as the break and recovery
	  6. If the eyes are observed to lose alignment and the patient does not report diplopia, this may indicate suppression
	*Norms – 5cm break and 7 cm recovery
	
	• Eye Alignment test (options include the cover tests)[35,43]
	• *Modified Thorington test, using the Bernell Muscle Imbalance Measure card tests (near and far).[7,51]* http://www.bernell.com

Saccades	• Developmental Eye Movement test [16,35,39]
	• *Northeastern State University College Optometry Oculomotor Test (NSUCO) of saccades [27,35]*
	
	  test without corrective lenses
	  Score is based on patient's ability, accuracy, and the presence of head or body movement during saccadic eye movements. See reference[27] for procedure and norms
	• *King-Devick [14,49]*

Pursuits	• NSUCO test of pursuits [27,35]
	  • Test without corrective lenses.
	  • Score is based on patient's ability, accuracy, and the presence of head or body movement during pursuit eye movements. See reference [27] for procedure and norms

Visual Scanning/Tracking	• *OSU Visual Tracing test?* • *Groffman Visual Tracing Test - Designed by Sidney Groffman, OD.,* www.bernell.com *(no studies)*

Visual Fields	• Confrontation field testing – finger counting[1,35]
	  • Test without corrective lenses.
	  • This test simultaneously screens for the extinction phenomenon that can accompany unilateral brain damage. See Addendum B.

* Should be trained by a vision specialist before performing fusion tests or accommodative tests.
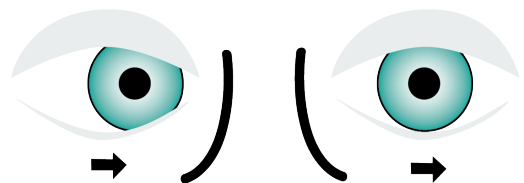
Visual field impairment and Cranial nerve injury is more likely to occur following moderate or severe TBI.[48]

- mayfieldclinic.com/PE-VisualFieldTest.HTM

Three Cranial Nerves that Supply Innervation to the Six
Extraocular Muscles of Each Eye

- ebmedicine.net/topics.php?paction=showTopicSeg&topic_id=23&seg_id=417

Nerve Palsy	Symptoms	Typical Examination Findings	Differential Diagnosis
Normal	n/a		n/a
Oculomotor (CN III) Palsy	Diplopia, horizontal and vertical		• Posterior circulation aneuryism • Brainstem lesion • Microvascular ischemia (if pupil spared) • Cavernous sinus disease
Trochlear (CN IV) Palsy	Torsional ("tilted") diplopia worse on downward gaze		• Brainstem lesion • Posterior circulation aneurysm • Cavernous sinus disease
Abducens (CN VI) Palsy	Horizontal diplopia on lateral gaze to the ipsilateral side		• Brainstem lesion • Elevated intracranial pressure • Cavernous sinus disease

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Resources for Neuro-Optometric/Sensorimotor Evaluation

OSU College of Optometry
338 W. 10th Ave
Columbus, OH 43210
(614) 292-1113

Galloway Eye Care
Jennifer Mattson, OD
Cassie Higbea, OD
5688 W. Broad St.
Galloway, OH 43119
(614) 853-2020

Riverview Eye Associates
Steven J. Curtis OD, FCOVD
3600 Olentangy River Rd, Unit B
Columbus, OH 43214
(614) 451-7244

Heritage Family Eye Care (primarily pediatric through college age)
Sara Huffman OD, MS
5123 Norwich St., Ste 120
Hilliard, OH 43026
(614) 850-6151

Emerald Eye Care
Dr. Michelle Denny, OD
6285 Emerald Parkway
Dublin, OH 43016
(614) 764-8956

Eyesite of Dublin
Jennifer Mattson, OD
6535 Perimeter Dr.
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Appendix A:
Expected Amplitude of Accommodation by Age[43]

Age	Expected Number (D)
15	13
18	12
21	11
24	10
27	9
30	8
33	7
36	6
39	5
42	4
45	3
48	2
51	1
54	0

Appendix B:
Rapid Confrontation Screening for Peripheral Visual Field Defects and Extinction

Rapid finger-counting confrontation screening requires four responses from the patient (panels A through D). The schematics are shown from the perspective of the clinician, with the patient's eye and covering hand shown in the grey oval. The combinations of fingers shown are examples only, although the clinician must always present either one or two fingers on each hand. A correct response from the patient is always 'two', 'three' or 'four' and never 'one'.

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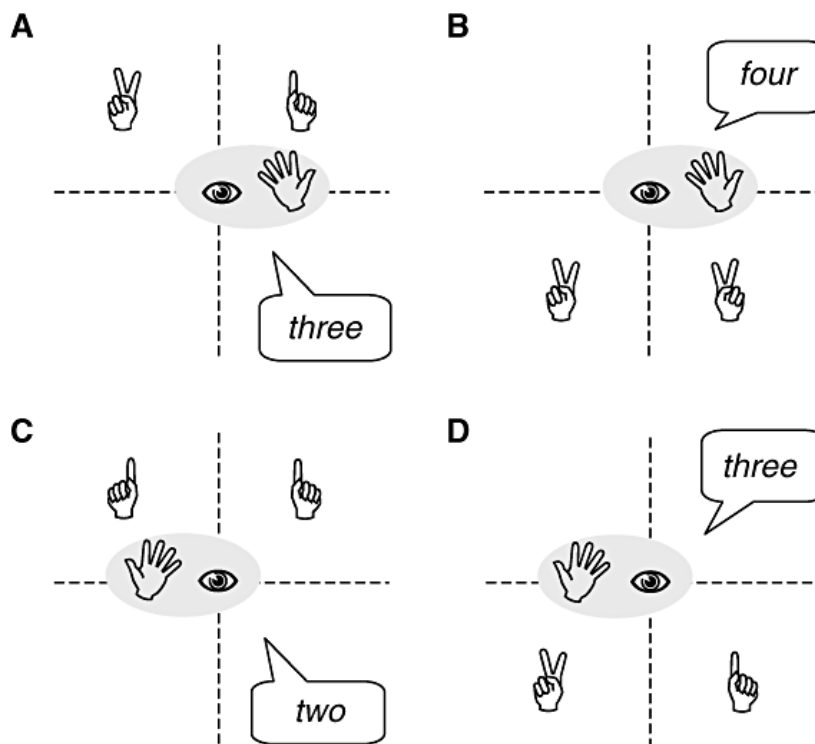**Completion date:** July 2017
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