Treatment of Visual Issues in Mild Traumatic Brain Injury (mTBI / Concussion)

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INTRODUCTION & SURVEY QUESTION
Objectives
- Understand the mechanism of mild Traumatic Brain Injury (mTBI / concussion)
- Understand basic anatomy and physiology of the eye
- Discuss the signs and symptoms of visual deficits after concussion
- Be able to perform testing for visual issues after concussion
- Determine which visual issues can be treated and understand treatment options
- Recognize when to refer to a specialist
- Discuss recovery of visual issues after mTBI

Concussion / mTBI
- Definition: Complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces
- Most commonly caused by a direct blow to the head, face, neck or elsewhere on the body with an “impulsive” force transmitted to the head, but does not require direct contact to the head

Results of concussion / mTBI
- Rapid onset of short-lived impairment of neurologic function that usually resolves spontaneously
- Neuropathological changes, but with acute symptoms reflecting a functional disturbance vs. structural injury
- Graded set of clinical symptoms that may or may not involve loss of consciousness, headache, confusion, lability, irritability, and sleep disturbance
Incidence
- Estimated 1.7 million Traumatic Brain Injuries (TBI) occur annually in the United States.
- Estimated between 1.6 - 3.8 million sports and recreational concussions occur annually.
- 50% of concussions are believed to be unreported.
- Likelihood of an athlete in contact sports experiencing a concussion is 20% per season.

Statistics
- American football is associated with the greatest number of mTBI in boys.
- Soccer is associated with the greatest number of mTBI in girls.
- 80 - 90% of concussions resolve in 7-10 days.
- Persistent symptoms (> 10 days) are reported in 10-15% of people with concussion.

Vision Statistics
- 30% of concussed athletes report visual issues in the first week.
- Most common vision issues include abnormalities in:
  - Saccades (30%)
  - Smooth pursuit (60%)
  - Vergence (45%)
  - Accommodation (65%)
  - Vestibulo-ocular Reflex (VOR)
  - Photosensitivity
Post Concussive Syndrome (PCS)
- Defined at having a prolonged recovery
- CDC states generally a period of 3 months to separate acute concussion from PCS
- PCS can affect 20-30% of people with mTBI

Second Impact Syndrome
- Second concussion that occurs before the first injury is healed
- Second blow may be minor but is associated with metabolic brain abnormalities
- Person undergoes rapid neurological decline and possible respiratory failure
- Can result in severe neurological impairment and even death

Pathophysiology of Injury
- On impact, glutamate causes neuronal depolarization (excitation) that causes an efflux of K+ from the neuron and an influx of Ca+
- The Na/K pump then must work harder to try and restore balance within the cell
- The pump requires an increase in the amount of ATP and the increased demand creates a large metabolic need for glucose
Pathophysiology of Injury

The sudden metabolic need for glucose causes a decrease in cerebral blood flow and lead to a cellular metabolic crisis.

Once the initial period of crisis has passed, the brain enters a period of decreased metabolism.

Constant high levels of Ca+ are toxic and cause intracellular edema and diffuse axonal death, and may also disrupt neuronal connectivity.

ANATOMY AND PHYSIOLOGY
Anatomy of the Eye

**Cornea**
- The transparent, curved structure at the front of the eye
- This is the first structure that light hits
- Light is bent to the greatest degree here
- Damage to the cornea can disturb the quality of the image as it falls on the retina

**Iris**
- The colored part of the eye - blue, brown, green, grey etc - that can be seen through the cornea
- Consists of fibers that control the opening of the pupil
Anatomy of the Eye

Pupil
- The black part of the eye in the middle of the iris
- It constricts or dilates to control the amount of light entering the eye
- Constriction and dilation are under autonomic nervous system control
  - Sympathetic and parasympathetic (fight or flight) components

Anatomy of the Eye

Lens
- The transparent disc (with both sides being convex) immediately behind the iris and pupil
- Can thicken and thin to provide focus, or accommodation
- Aging causes thickening of the lens and accommodation gets weaker, which requires external lens (glasses) to improve

Anatomy of the Eye

Vitreous Chamber
- Filled with gel like substance
- Aging can cause gel to liquefy and trapped particles are released causing “floaters”
Anatomy of the Eye

Retina
- The photosensitive layer of millions of nerve cells that line the back of the eyeball
- Includes the optic disc
- Receives the pattern of reflected light from objects
- Contains a macula that is temporal to the optic disc and contains the fovea (central vision)
- Surrounding retina provides peripheral vision
- The macula and fovea contain photoreceptor cells called rods and cones

Anatomy of the Eye

Rods and Cones
- Rods have greater sensitivity to dim light
- Cones have greater sensitivity to color and high intensity light

Normal Eye Anatomy
Visual Pathway

- Begins with photoreceptor cells and exit through the optic nerve
- Synapse occurs with bipolar cells, which synapse with ganglion cells
- Information then moves to the association areas / visual cortex of the brain and sent out for further decision making
- Approximately 30% of the cortex is dedicated to vision
- It is estimated that up to 90% of the brain has an indirect connection to vision

Visual Pathway

- Eye movement system consists of 6 pairs of eye muscles
- All muscles are controlled by CN III (oculomotor), CN IV (trochlear), and CN VI (abducens)
- Reflexive movements are controlled through vestibular connections at the midbrain level

Visual Pathway

- Visual area of the brain
- Optic nerve
- Optic chiasm
- Optic tract
- Retina
- Visual cortex
Signs and Symptoms of Visual Disturbance after mTBI

- Dizziness
- Blurred vision
- Light sensitivity
- Difficulty reading / focusing
- Diplopia
- Oscillopsia
- Headaches
- "Fogginess"

CLINICAL TESTING

Subjective Tests
- Post Concussion Symptom Scale (PCSS)
- Dizziness Handicap Inventory
Post Concussion Symptom Scale (PCSS)

- 22 items
- Max score of 132 to min score of 0
- Answers are graded 0 (no symptoms) to 6 (severe symptoms)
- Moderate test – retest reliability
- Able to distinguish between concussed and non-concussed athletes

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Dizziness Handicap Inventory (DHI)

- 25 items
- Max score of 100 (28 points for physical, 36 points for emotional, and 36 points for functional) to min score of 0
- Answers are graded 0 (never), 2 (sometimes), and 4 (always)
- Higher score = greater the perceived handicap due to dizziness
  - Mild: 0-30
  - Moderate: 31-60
  - Severe: 61-100

www.rehabmeasures.org
Clinical Testing

- Eye movement control relates closely to the functional integrity of the brain.
- Eye movement paradigms have been used to study the role of things such as attention, working memory, response inhibition, speed of information processing, predictive behavior, and motor planning.
- Visuospatial orienting of attention comprises disengagement, movement, and re-engagement.

Clinical Testing

- Poor eye movement can create additional dysfunction such as decision making under pressure, short term spatial memory, motor sequencing and execution, visuospatial processing and integration, visual attention, and subcortical brain function.
- Brain injury causes difficulty with disengaging, shifting, and re-engaging of vision, as well as ability to disregard irrelevant information to produce appropriate response.

Sideline / Clinical Tests

- King Devick Test
- Vestibular/Ocular Motor Screening (VOMS)
  - Best when performed with other assessments of balance, which balance tests used alone failed to show abnormalities in 10% of mTBI
    - Balance Error Scoring System (BESS)
    - Standardized Assessment of Concussion (SAC)
    - Sport Concussion Assessment Tool, version 3 (SCAT3)
King Devick Test
- Based on measurement of speed of rapid number naming
- Takes approximately 2 minutes to administer
- Assesses impairments of eye movements, attention, and language
- Tests function of parts of brainstem, cerebellum, and cerebral cortex

King Devick Test
- Performed by reading aloud a series of single digit numbers from L to R on 3 cards
- Sum of 3 card time makes summary score for entire test
- High degree of test-retest reliability
- Ideal to have baseline measure for comparison
Dizziness is reported by 50% of concussed athletes.
- Could represent vestibular and/or visual etiology
- Associated with 6.4 times greater risk of protracted recovery (> 21 days)

VOMS consists of 5 brief assessments in 5 domains:
- Smooth pursuit
- Horizontal and vertical saccades
- Convergence
- Horizontal and vertical VOR
- Visual motion sensitivity
Takes approximately 5 – 10 minutes to administer

Any individual score of ≥ 2 increases probability of mTBI by 46%
Near point convergence of ≥ 5 cm increased probability of mTBI by 34%
Developed due to lack of pursuits, convergence, or accommodation in King Devick Test
- All have been found as important indicators of dysfunction in mTBI
Clinical Tests

- Oculomotor control
- Smooth pursuit
- Saccades
- Near point convergence (NPC)
- Vestibulo-ocular reflex (VOR)
- Visual acuity
  - Static
  - Dynamic

Oculomotor Control

- Oculomotor
  - Ocular alignment
  - Nystagmus
    - End point
    - Spontaneous
    - Gaze evoked
- Tested by asking patient to follow a moving object while head remains stationary
Alignment video

Smooth Pursuit

- Allows the eye to maintain gaze at a constant speed on a moving object
- Depends primarily on foveal activation and requires voluntary participation involving the cerebral cortex
- Tested by asking patient to follow object moving at a constant speed (1 Hz) while the head remains stationary

Smooth Pursuit video
Saccades

- Stimulated by images in the peripheral system, where detection of motion or change in light intensity results in rapid eye movement to bring the object into the foveal field
- Frequently abnormal after concussion, which relate to impairments in executive function, attention, and memory secondary to inability to disengage

Saccades

- Tested by asking the patient to look back and forth between two targets rapidly while the head remains stationary
- In VOMS study, 33% of concussed athletes reported increase in symptoms with vertical saccades

Saccades video
Vergence

- Includes convergence and divergence
- Associated with accommodation
  - Convergence with accommodation
  - Divergence with relaxation of accommodation

Convergence

- The ability to smoothly bring the eyes together in midline to observe objects that are near as single image
- Normal is < 5 centimeters

Near Point Convergence

- Tested by asking patient to follow target in toward center of nose
- Abnormal result is blurring or doubling of target
- At the point of blurring or doubling of target, or when one or both eyes move away from target, the distance to the target from the nose is measured
- Patient should wear glasses if needed for near vision
- Fatiguing can occur with multiple tests
Accommodation

- Ability to bring near objects into clear focus automatically without strain
  - Requires pupil constriction
- Relaxation of accommodation allows for objects in the distance to come into focus
  - Requires pupil dilation

Convergence video

Vestibulo-Ocular Reflex (VOR)

- Vestibular input is used to hold images stable on the retina during head rotations
- With connections between eye muscles and semicircular canals, movement is determined as either internal or external
- Based on provided information the VOR is able to direct appropriate head or eye movement
Vestibulo-ocular Reflex (VOR)

- Tested by asking the patient to focus on a target while the head is moved horizontally and vertically.
- Assesses ability of patient to stabilize gaze while head moves at 2 Hz.
- Need to determine the appropriate speed patient is able to successfully perform gaze stability.

Dynamic Visual Acuity

- Functional measure of presumed VOR.
- Assesses patient’s ability to see clearly while actively moving the head.

VOR video
Dynamic Visual Acuity

- Tested by asking patient to move head side to side at 2 Hz and read lowest line on Snellen eye chart that is clear.
- Should assess static visual acuity first.
- Difference should be no more than 2 - 3 lines.

CLINICAL TREATMENT

Concussion / mTBI Treatment

- Consensus statement on concussion in 2016 reports 11 “R’s” of sports related concussion management:
  - Recognize
  - Remove
  - Reevaluate
  - Rest
  - Rehabilitation
  - Refer
  - Recover
  - Return to sport
  - Reconsider
  - Risk reduction
  - Risk reduction
Concussion / mTBI Treatment

- Minimal activity for at least one week
  - No sports / play
  - Limited visual activities
  - Need to “shut down”
- Gradually add activities back in after the first 7 days
- Monitor headaches
- Work on
  - Vision
  - Balance
  - Dizziness
  - Cervical motion

Increase intensity of exercise
- Can increase faster with headaches, though don't allow to get too high
- Must have dizziness under control before increasing activity
- Add cognitive challenges to activities
- Increase multi-tasking activities
- Gradual return to play / sport
  - Sport specific activities
  - Practices without impact

Clinical Treatment

- Smooth pursuit
- Saccades
- Near point convergence (NPC)
- Vestibulo-ocular reflex (VOR)
- Photophobia (light sensitivity)
Smooth Pursuit

- Tracking exercises
  - Figure 8
  - Flashlight chases
  - Go through a page of print and circle all the a’s, etc
  - Pinata or bouncing ball

Pursuits

- Person should not move their head and follow target by only moving their eyes
- Movements should be smooth and person should reach all end ranges in quadrants to ensure no cranial nerve involvement

Thumb Rotations

- Place thumb in front of the face, with elbow slightly bent
- Perform an H, X, and O, clockwise and counterclockwise, while following shapes with the eyes
Saccades

- Using 2 targets, perform quick eye movements between them
- Be sure to stay within patient’s ability
- Limit time to 1 – 2 minutes to avoid increase in symptoms

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Saccades

- Place numbers on a page in random order
- Perform exercise by pointing to numbers in order
- Read random line of numbers across as quickly as able
- Plain background to busy background to ambulation

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Convergence Insufficiency

- Pencil pushups
- Brock String
- Do not allow patient to turn or tilt their heads
- Many times insufficiency is a spatial problem and not a misalignment, especially in concussion
Convergence Insufficiency

Pencil Pushups
- Hold pencil tip at arms length
- Slowly bring pencil in toward tip of nose until end doubles or blurs
  - Glasses should be worn if needed
- Pull end back slightly to clear and hold for up to 10 seconds
- Pull pencil back slowly (divergence) to starting position and repeat

Pencil Pushup video

Convergence Insufficiency

Brock string
- 3 colored beads on a 3 foot piece of string
- Patient focuses on far bead and ensures they see appropriate peripheral image
- Move toward next closest bead and repeat until at near bead
- If patient is unable to see appropriate crossing, then they can touch the bead to use sensory input to assist with focus
Convergence Insufficiency

- Insufficiency is observed in 5% of healthy populations
- Brock string also helps with accommodation
Gaze stabilization (VOR)

- Work within patient’s tolerance
- Head movements can increase dizziness, if present
- In VOMS study, VOR was associated with the highest percentage of symptom provocation (61%)
- Target must remain in focus
- Exercises
  - x1 viewing
  - x2 viewing

Gaze Stabilization (VOR)

- x1 Viewing
  - Target remains stationary while the head moves
  - Eyes remain focused on target during head movements
  - 30 – 45 degrees of motion

x1 viewing video
Gaze Stabilization (VOR)

x2 Viewing
- Target is moving in opposite direction of head movement
- 30 – 45 degrees of head motion with less motion in target

x2 viewing video

Gaze stabilization (VOR)
- Standing
- Busy background
- Foam
- Ambulating
  - Level surfaces
  - Unelevel surfaces
Photophobia (Light Sensitivity)

- Defined as “abnormal sensitivity to light, especially of the eyes”
- Post concussion syndrome retains photophobia > 6 mos after injury
- Chronic darkness will increase perception and pain of light
- Contributes to headache

Photophobia

- Wear sunglasses and brimmed hats to help limit
- Gradually increase exposure to light
- FL-41 tints block blue wavelengths, which likely induce sensitivity, and have been shown to reduce migraine frequency by ½
- Botox also helped to reduce photophobia associated with post traumatic headache
- Referral to neuro-optometrist is primary treatment
Clinical Treatment

- Be careful not to overstimulate patient!
- Symptoms can be cumulative throughout the day, so encourage frequent breaks
- Lack of sleep exacerbates symptoms
- Work closely with physician and neuro-optometrist

Referrals

- Neurologist / Concussion Specialist
  - ImPACT testing
  - MRI / CT scan
  - Neuro testing
- Neuro-optometrist
  - Acuity testing
  - Vision testing
- Behavioral Optometrist

RECOVERY AND GOALS
Recovery
- There is no set time frame for recovery
- Every person is different and recovery depends on severity of symptoms
- Impaired eye movement function correlates well with severity of post concussive symptoms and limitations in ADL's

Factors associated with prolonged recovery
- Age
  - Adolescents require more time
- Headaches
- Post concussive headaches or migraines
- Symptoms
  - "Fogginess" symptom has higher symptom scores overall

Goals
- Patients should be symptom free before returning to play / work
- Goals should be functional and task specific
- Must address ALL symptoms, not just specific ones as many overlap
Red Flags

- Visual field cuts
- Tingling in hands and/or feet when looking down
- Constant headaches/migraines that do not change in intensity or improve over time

Questions?