Oculomotor deficits in mild Traumatic Brain Injury (mTBI)

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Disclosures

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Background

Concussion/mild TBI

Oculomotor Deficits

Reportedly occur in 40-90% in acquired brain injury (mTBI is a sub-set of this)
Assessment of eye movements

SUBJECTIVE or CLINICAL

Symptoms-based
Self-reported
Visual inspection

OBJECTIVE or INSTRUMENTED

Quantitative

Vestibular/Ocular-Motor Screening (VOMS) for Concussion

<table>
<thead>
<tr>
<th>Vestibular/Ocular Motor Test</th>
<th>Not Tested</th>
<th>Headache 0-10</th>
<th>Dizziness 0-10</th>
<th>Nausea 0-10</th>
<th>Fogginess 0-10</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASELINE SYMPTOMS:</td>
<td>N/A</td>
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<tr>
<td>Smooth Pursuits</td>
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<tr>
<td>Saccades – Horizontal</td>
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<tr>
<td>Saccades – Vertical</td>
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<tr>
<td>Convergence (Near Point)</td>
<td></td>
<td>(Near Point in cm): Measure 1: Measure 2: Measure 3:</td>
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<tr>
<td>VOR – Horizontal</td>
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<td></td>
</tr>
<tr>
<td>VOR – Vertical</td>
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<tr>
<td>Visual Motion Sensitivity Test</td>
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</tbody>
</table>
Types of eye movements

**Saccades**
- Self-paced
- Reflexive or Pro-saccades
- Memory-guided (step or gap)
- Anti-saccades

**Fixations**
- <30°/sec velocity
- >100ms duration
- <2° amplitude

**Smooth Pursuit**
- >30 & <100°/sec velocity
- >60ms duration
- >2° amplitude

**Memory Guided Saccades**
- Response
- Delay
- Target
- Fixation
Why care about eye movements?

- Eye movements involve a vast array of different brain regions
- Overlap exists between eye movement and locomotor/balance circuitry
- Reflect cognitive, visual and motor deficits that can impact locomotion/balance
- Diagnose dysfunction
- Monitor rehabilitation / recovery
Issues with previous mTBI literature

Samples
- Few studies and small number of participants
- Various times following head injury with varying diagnosis criteria
- Differing populations; sports, military, civilians, young, old etc.

Types of eye movement assessment
- No “gold-standard” assessments
  - For example; despite internationally standardized assessment for anti-saccades being available, it is not used
- As a result, various testing paradigms have been employed (many only horizontal)
  - For example;
    - Smooth pursuits with varying trajectories, velocities or target visibility
    - Saccades, voluntary or reflexive, step/gap protocols, self-paced, anti- or pro-saccadic tests, memory-guided
    - Fixation, stability (but performed while doing other tasks e.g. balancing on a board)

Technology used to monitor eye movements
- Eye-trackers
  - Range of sampling frequencies (e.g. 30Hz to >1000Hz)
    - Cannot accurately obtain some metrics with low sample rates
  - Static or tethered devices primarily used
    - Paradigms lack functional impact that dynamic testing can provide
    - May not be practical for use in field or pitch-side
Aims

1. Examine eye movements during static tasks in chronic stage mTBI
   - We hypothesized that ocular motor deficits would be present during static testing compared to controls

1. Preliminary examination of eye movements during static and functional tasks in early stage mTBI
   - We hypothesize that ocular motor deficits will be more prominent during functional (walking or turning) rather than static tasks compared to controls
Methods – Chronic stage mTBI

Study 1

Chronic mTBI (>3 months post-injury and report balance issues) vs controls

Otometrics VNG tethered eye-tracker
• 60Hz
• Static tests
  • Eye movements; saccades, smooth pursuits
Results – Chronic mTBI

No differences in metrics
Study 2

Early mTBI (with 12 days of injury) vs controls

Tobii Pro Glasses 2 mobile eye-tracker
- 100Hz
- Static and Dynamic tests
  - Saccades
  - Fixations (and smooth pursuits)
  - Pupil diameter
  - Vestibular ocular reflex

Static testing - Vestibular ocular motor screen

- Smooth Pursuits (Horizontal & Vertical)
  - Tests ability to follow a slowly moving target
  - Both patient and clinician are seated
  - Patient follows finger with eyes
  - Do not move head, just eyes
  - Rate symptoms (0-10)

- Saccades (Horizontal & Vertical)
  - Tests ability of eyes to move quickly between targets
  - Both patient and clinician are seated
  - Clinician holds fingers 3" apart
  - Patient initially looks L-R
  - Do not move head, just eyes
  - Rate symptoms (0-10)

- Convergence
  - Measures ability to view a near target without double vision
  - Patient holds target with 14-point "X" at arm's length
  - Patient brings target toward eyes focusing on the "X"
  - Stop when they see double
  - Rate symptoms (0-10)

- Visual Motion Sensitivity
  - Tests visual motion sensitivity & ability to inhibit vestibular induced eye movements using visual motion
  - Patient holds arm outstretched in front with thumbs up
  - Turn body as a unit to 40 deg from midline turning on trunk
  - Use metronome 60 bpm
  - Rate symptoms (0-10)

- Vestibular-Ocular Reflex (Horizontal & Vertical)
  - Tests ability to stabilize vision as head moves
  - Clinician holds target 3" from patient's eye level
  - Patient initially turns head L-R 10x
  - Keep eyes focused on target
  - Use metronome 180 bpm
  - Rate symptoms (0-10)
  - Repeat with patient looking up/down
Functional testing - Walking

Single Task

Dual Task - Auditory Stroop

Hi, Low, Hi, Hi, Low
Turning course

Turning course with dual-task

Turning course fast walking

Functional testing - Turning
Preliminary Results – Static Saccades

Saccades (Horizontal & Vertical)
Tests ability of eyes to move quickly between targets
Both patient and clinician are seated
Clinician holds fingers 3” apart
Patient initially looks L-R
Do NOT move head, just eyes
10 reps as quickly as possible
Rate symptoms (0-10)
Repeat with patient looking Up-Down

- Possibly differences between groups
  - Inhibitory control issue?
- Earlier stage following injury
- Sampling frequency of device??

<table>
<thead>
<tr>
<th>Peaks Velocity</th>
<th>Horizontal</th>
<th>Vertical</th>
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<tbody>
<tr>
<td>Control</td>
<td>600</td>
<td>550</td>
</tr>
<tr>
<td>mTBI</td>
<td>650</td>
<td>600</td>
</tr>
</tbody>
</table>

Degrees per second

Time

Velocity
Preliminary Results – Functional Tasks

Clearer differences in metrics
Summary

- Ocular motor deficits may be a useful for diagnosis and recovery tracking in mTBI
  - Functional deficits may be particularly useful
- Chronic mTBI subjects who present with balance issues may not have ocular motor deficits during static tests
  - Cautious interpretation due to low eye tracker sampling frequency and limited range of tests / metrics
- Early stage mTBI may have ocular motor deficits, which are possibly more prominent during functional rather than static tasks
  - Cautious interpretation due to small sample of preliminary data
- Future work with a larger cohort of early stage mTBI subjects will establish findings
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