Background
- Education
  - Pacific University College of Optometry
- Current
  - Primary Care OD
    - Retina Institute of Hawaii
  - Clinical Professor
    - Pacific University College of Optometry
    - University of Missouri College of Optometry
  - Research Consultant
    - Duke University
  - Principal
    - Engine Sports Lab

Lecture Outline
- Visual symptoms of Concussion and how it impacts athletic and academic performance
- Ocular evaluation for post-concussion syndrome
- Treatments for post-concussion
- Future treatments and preventive measures

Concussions
- Traumatic Brain Injury (TBI)
  - Results from acute impact to the head causing brain dysfunction
- Concussion
  - Form of a mild TBI
  - Induced by biomechanical forces
  - Direct or Indirect blow to head

Epidemiology
- Up to 3.8 million concussion occur annually
  - Boys HS Football - Highest Rate
  - Girls HS Soccer
- About 80% of concussions may go undiagnosed
  - < 10% of sports related concussion result in loss of consciousness
  - ~50% there are no immediate symptoms
Visual Symptoms
- Double vision
- Blurry vision
- Light sensitivity
- Reading difficulties
- Eye strain
- Vision-Derived Nausea
- Visual Anxiety
- Visual Inattention

Other Visual Problems
- Reduced peripheral awareness
- Car Sickness
- Mid-line Shift
- Poor balance
- Visual Vestibular Mismatch
- Oculomotor Dysfunction

Ocular health changes
- Dry eye
- Retinal nerve fiber layer thinning
- Optic nerve head changes
- Macular thinning

Concussion Patient Workup
- Concussion Questionnaire
  - Focus on near work symptoms
- OCT of Macula and RNFL
- Dilated Fundus Exam / Fundus photos
- Complete binocular vision assessment
  - Consider future diagnostics
    - Visual field testing
    - VEP
    - Dry Eye workup

Visual Questions to Ask
- Distance/Near vision blur
- Double vision in distance or near
- Eye fatigue
- Losing place while reading
- Difficulty with screens
- Dry eye
- Light sensitivity

Accommodative Testing Norms

<table>
<thead>
<tr>
<th>Testing</th>
<th>Normative Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accommodative Amplitude</td>
<td>Avg: 18.5 – 1/3 Age</td>
</tr>
<tr>
<td></td>
<td>Min: 15 – 1/3 Age</td>
</tr>
<tr>
<td>Binocular Crossed Cylinder</td>
<td>+0.50 sph</td>
</tr>
<tr>
<td>Negative Relative Accommodation (NRA)</td>
<td>&gt; 2.00 (+/- 0.50)</td>
</tr>
<tr>
<td>Positive Relative Accommodation (PRA)</td>
<td>-2.37 (+/- 1.00)</td>
</tr>
<tr>
<td>Monocular Estimation Method</td>
<td>+0.75</td>
</tr>
<tr>
<td>Accommodative Facility Testing</td>
<td>Monocular: +/- 2.00 (8-12yo – 7cpm)</td>
</tr>
<tr>
<td></td>
<td>over 12 yo: 11cpm</td>
</tr>
<tr>
<td></td>
<td>Binocular: +/- 2.00 (8-12yo – 5cpm)</td>
</tr>
<tr>
<td></td>
<td>adults – 10cpm</td>
</tr>
</tbody>
</table>
**Vergence Testing Norms**

<table>
<thead>
<tr>
<th>Testing</th>
<th>Normative Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative Fusional V (BI)</td>
<td>Distance x/7/4</td>
</tr>
<tr>
<td>Near – 13/21/13</td>
<td></td>
</tr>
<tr>
<td>Positive Fusional V (BO)</td>
<td>Distance 9/19/10</td>
</tr>
<tr>
<td>Near 17/21/11</td>
<td></td>
</tr>
<tr>
<td>Vergence Facility</td>
<td>3 BI / 12 BO flipper – 15cpm</td>
</tr>
<tr>
<td>Near Point of Convergence</td>
<td>Accommodative target 5cm/7cm</td>
</tr>
<tr>
<td>Penlight &amp; RG glasses – 7cm/10cm</td>
<td></td>
</tr>
</tbody>
</table>

**Most Common Visual Changes in Concussion**

- 4 Visual Changes That Impact Learning
  1. Accommodative dysfunction
  2. Vergence dysfunction
  3. Saccadic dysfunction
  4. Light Sensitivity (Photophobia)

**Accommodative Dysfunction**

- Accommodative Insufficiency
  - Low PRA, Large lag of Accommodation
  - Low amplitude of accommodation
- Accommodative Infacility/Spasms
  - Low NRA/PRA, Low Accommodative facility
  - May have low NFV/PFV
- Accommodative Excess
  - Lead on BCC, Low NRA, Low PFV

**Accommodative Insufficiency (AI)**

**Symptoms**
- Blurred vision at near
- Discomfort and strain associated with near tasks
- Fatigue associated with nearpoint tasks
- Symptoms worse at end of day
- Difficulty with attention and concentration with reading

**AI Evaluation**

- Accommodative Amplitude
  - Positive Relative Accommodation - 2.00 or less
  - Binocular crossed cylinder
  - Base-out to blur
- Accommodative Facility
  - Binocular Accommodative facility
  - Near-far quickness test
  - Less Flipper
- Accommodative Lag
  - Near point retinoscopy
  - MEM

**AI Treatment**

- Treatment
  - Low power readers
  - Bifocal readers
  - Multifocal contacts
  - Vision therapy
    - Accommodative facility training
    - Computer based training
Vergence Dysfunction

- Convergence Insufficiency
  - Near asthenopia, words moving on the page, diplopia, poor concentration
  - May also have Accommodative Insufficiency too
  - Reduced Near Point of Convergence
  - Lead on BCC
  - Low NRA ranges
  - Low PFV ranges at near

Convergence Insufficiency

- How it affects learning
  - Decreased reading
  - Headaches/Eyestrain
  - Double vision
  - Hates reading

Double vision makes it difficult to read and comprehend.

Convergence Insufficiency

- Amplitude
  - Base in/out ranges at near
  - Near point of convergence

- Facility
  - Base in/out flippers
  - Accommodative facility

Pseudo CI

- Truly AI
- Plus acceptor
- Low PRA
- High NRA
- Lag on BCC
- AI with a near Exophoria
- NPC more reduced on non-accommodative target

Near Point of Convergence

Quick evaluation of near point stress and risk for CI
42% of concussed athletes had CI

Treatments for CI

- Base In Prism Glasses
- Reading glasses
- Vision therapy to improve convergence ability
Saccadic and Pursuit Eye Movements
- Saccades – Decreased reading speeds
- Pursuits – decreased tracking abilities

Saccadic/Pursuit Dysfunction
- How it affects learning
  - Nausea in crowded areas
  - Slow reading vision
  - Lose place while reading
  - Difficulty tracking
- Assessment
  - VOMS testing
  - Saccadic
  - Pursuits
  - VOR testing

Treatment

Light Sensitivity
- Symptoms
  - Discomfort/Eye pain with bright lights
  - Flashes of light or spots in vision
- Causes
  - Photophobia
    - Traumatic Iritis
    - Pupil injury
    - Dry eye

Light Sensitivity Treatment
- Sunglasses / Tinted Lens
- Tinted Contacts
- Dry eye medications
- Anti-Inflammatory drops

Visual Signs of Worse than Concussion
- Afferent Pupillary Defect
- Flashes or Floaters
- Visual Field Defects
- Cranial Nerve Palsy
- Reduced Visual Acuity
- Eye pain on movement
Sensorimotor Evaluation

- VOMS (Vestibular Ocular Motility Screening)
- King Devick Card
- DEM (Developmental Eye Movement Test)

VOMS

- Vestibular Ocular Motor Screening
- 90% Accuracy
- Five tests of the vestibular and ocular motor systems
  1. Pursuits
  2. Saccades
  3. Near Point of Convergence
  4. Vestibular Oculo-Reflex
  5. Visual Motion Sensitivity

King Devick Card

- Quick sideline concussion screener
- Test Saccadic Eye Movements
- Ask if there are any symptoms of eye strain or discomfort
- Learned affect is good here
- Requires a baseline

Developmental Eye Movement Test
Diagnostic Tools
- OCT – Macula and Optic nerve head
- Visual evoked potential
- Electroretinography
- Visual field
- Microperimetry

OCT - Macula
- Central retinal thickness has been shown to change post concussion
- Retinal edema due to iritis
- Thickening of retinal vessels
- ERM/ILM thickening

OCT Macula
- Inner retinal thinning as been found in patients with multiple concussions
  - Majority of ganglion cells are located in the inner retinal layer
  - Average GCIPL thickness was also significantly associated with better BCVA and visual functioning scores
- Studies have also found significant macular thickening
  - Potentially due to CME from iritis or micro RVO

OCT Optic Nerve Head
- Optic nerve head cupping
- Retinal nerve fiber layer changes
- Optic neuropathy

OCT of Optic Nerve
- Retinal nerve fiber thinning
  - RNFL and RGC become thin around 2 weeks after TBI
  - Visual defects however are not always present
- Also possible to have RNFL thickening
  - Due to edema
  - Possible association with anterior optic neuritis

Visual Evoked Potential
- For subtle/mild cases of TBI history, electrophysiology can help detect visual pathway changes
- Magnocellular (where stream) deficits have been reported
  - Increased motion sensitivity
  - Elevated critical flicker frequency threshold
- Increased P100 latencies >119 ms
- Decreased amplitude > 14.75mV
**Electroretinography**
- Decrease in pattern ERG correlates with decrease in RNFL
- Reduced cellularity in ganglion cell layer and damage to optic nerve
- Decrease in amplitude of the photopic negative response
- ERG detects morphometric changes

**Visual Field Changes**
- Result of damage to any portion of the visual pathway from the visual cortex to the retina
- Constriction of the fields
- Isolated or multiple scattered defects
- Homonymous hemianopsia with/without neglect

**Microperimetry**
- Central visual field testing
- Correlates with fundus photo to monitor vascular changes
- Tracks fixation
- Biofeedback training for visual field loss

**Management**
- 80% of symptomatic concussions resolve within 3 weeks
  - Visual issues can last for 3 months to 1 year
- No same day Return to Play
  - Must be cleared by Physician
- Prescribed physical/cognitive rest until asymptomatic
  - 1 week period of rest decreased Sx and increased cognitive score in 60% of patients

**Team Management**
- Multidisciplinary team management
  - Family Physician
  - Sports Med
  - Physical therapy
  - Occupational therapy
  - Eye care physician
  - Vestibular
  - Behavioral

**Future Tools**
Senaptec Tablet
- Portable tablet
- Baseline sensory profile
- Sideline Retest
- Post Concussion Rehabilitation

FitLight
- Reaction light stimulus
- Evaluate players reaction time
- Assessment and Enhancement tool
- Improve and treat post concussion

Case 1
- 15 year old Female, concussion post soccer injury
- CC: Headaches, eye strain while reading
- VA: 20/20 OD,OS,OU at distance and near
- Ocular health examination: WNL

Binocular vision examination
- Phoria: 10 exophoria at near
- 2 exophoria at distance
- NPC: 9 cm
- NRA: +2.00D (LOW)
- BCC: +0.50D
- NFV (BI range) – 14/20/12
- PFV (BO range) – 9/11/4 (LOW)
- PRA: -4.00D

Case 1
- Diagnosis?
  - Convergence Insufficiency
- Treatment
  - Base In Prismatic Lens with low power reading glass
  - Vision therapy to improve convergence ranges

Case 1
- 1 month Follow-Up
  - Able to read comfortably and focus up close for extended periods without headaches/discomfort
- Long term Follow-Up
  - After 3 months her visual symptoms resolved with vision therapy
  - Recent follow up, graduated and playing collegiate soccer
Case 2
- 8 year old boy
- CC: Nausea/Vomiting after near work. Symptoms present for 6 months
- Recent concussion playing football.
- VA: 20/20 OD, OS, OU
- Ocular health examination: WNL

Binocular vision examination
- Near phoria: 6 exophoria
- Distance phoria: 1 exophoria
- NPC: 16 cm
- NRA: +3.00D
- BCC: +1.50D
- NFV (BI range) – 6/10/2 (LOW)
- PFV (BO range) – 20/25/14
- PRA: -1.00D (LOW)

Accommodative Insufficiency
- Large lag of accommodation
- Decreased BI ranges at near
- Low amplitude of accommodation
- Pseudo-CI
- NPC improved to 4 cm with +1.50 readers
- AI with near exophoria

Management
- Prescribed
  - +1.50 add bifocal glasses
  - Home vision therapy with flippers and convergence exercises
- 1 month follow up
  - Immediate reduction in symptoms with glasses
  - Able to read comfortably without having nausea or vomiting

Questions
- Mahalo
- Any specific questions
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  - 808-398-3766