Practical Management of Non-Strabismic Binocular Vision Anomalies

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Outline

Binocular Vision Evaluation
- Vergence
- Accommodation
- Oculomotor
- Normative Data

Non-strabismic binocular vision anomalies
- Convergence Insufficiency
  - Association with mTBI
  - Accommodation insufficiency
  - Accommodative spasm
  - Ocular motor deficit
  - Learning disability

Goals

1. To present a binocular vision testing protocol that can be integrated into a primary care clinic
   - Efficient testing protocol
   - Minimal additional tools needed to obtain data
   - Increase rate of diagnosis of binocular vision problems
   - Increase treatment and referrals for binocular vision problems
2. To provide sample clinical cases demonstrating treatment of common binocular vision anomalies
3. To support translation of clinical research to clinical practice

Binocular Vision Exam

- Initial evaluation – comprehensive eye exam with cycloplegic refraction

Vergence/Binocular Testing
- Phoria
  - Cover test-distance (D) and near (N)
  - Near point of convergence (break/recovery)
    - Targets: accommodative, light, red/green glasses or red lens
  - Fusional vergence ranges
    - Step Vergence - Free space (prism bars)
    - Positive and Negative Fusional Ranges @ D + N
  - Vergence Facility (12BO/3BI)

Accommodative Testing
- Amplitude of Accommodation (Amp)
  - Push up/Push away
- Accommodative Facility
  - Flippers +2.00/-2.00
  - Monocular (MAF) and Binocular (BAF)
- Accommodative Response
  - Dynamic retinoscopy - Monocular Estimation Method (MEM)

Vergence/Accommodation Interaction
- AC/A ratio
- NRA/PRA
- Binocular accommodative facility (+/-2.00 D flippers)
Binocular Vision Exam

- **Eye Movements**
  - Fixation Stability
  - Saccades and Pursuits
  - Observation – NSUCO oculomotor test
  - Visual-Verbal
  - Developmental Eye Movement Test (DEM)
  - King-Devick Test

- **Vergence Testing Norms**

<table>
<thead>
<tr>
<th>Test</th>
<th>Break</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPP - distance</td>
<td>0-4 eso ± 1.9</td>
<td></td>
</tr>
<tr>
<td>NPP - near</td>
<td>0-4 eso ± 3.0</td>
<td></td>
</tr>
<tr>
<td>NPC - photometrics</td>
<td>2.2 ± 4.6  (break)</td>
<td>11.4 ± 7.2 (tests)</td>
</tr>
<tr>
<td>NPC - near lens</td>
<td>6.9 ± 7.5</td>
<td>11.4 ± 10.7</td>
</tr>
<tr>
<td>NPC – acc tgt</td>
<td>2.9 ± 3.5</td>
<td>6.9 ± 7.0</td>
</tr>
<tr>
<td>DAEVF (stop)</td>
<td>60 ± 2</td>
<td>6 ± 2</td>
</tr>
<tr>
<td>BPEPF (stop)</td>
<td>17 ± 7</td>
<td>11 ± 6</td>
</tr>
<tr>
<td>NPCF (stop)</td>
<td>11 ± 3</td>
<td>7 ± 3</td>
</tr>
<tr>
<td>NPCF (stop)</td>
<td>18 ± 8</td>
<td>15 ± 6</td>
</tr>
<tr>
<td>Vergence facility (12 HR3 BO)</td>
<td>15 ± 3 cpm</td>
<td></td>
</tr>
</tbody>
</table>

- **Accommodation and Binocular Interaction Norms**

<table>
<thead>
<tr>
<th>Test</th>
<th>Range ± Std dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplitude of Accommodation (push-up)</td>
<td>18 -1/-3 age ± 2 D</td>
</tr>
<tr>
<td>Dynamic retinoscopy (MEM)</td>
<td>+0.50 ± 0.25 D</td>
</tr>
<tr>
<td>Monocular accommodative facility</td>
<td></td>
</tr>
<tr>
<td>6-12 years</td>
<td>7 ± 2.5 cpm</td>
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<tr>
<td>13-30 years</td>
<td>11 ± 5.0 cpm</td>
</tr>
<tr>
<td>Binocular accommodative facility</td>
<td></td>
</tr>
<tr>
<td>8-12 years</td>
<td>5 ± 2.5 cpm</td>
</tr>
<tr>
<td>Adults</td>
<td>10.0 ± 5.0 cpm</td>
</tr>
<tr>
<td>NRA</td>
<td>+2.00 ± 0.80 D</td>
</tr>
<tr>
<td>PRA</td>
<td>-2.37 ± 1.00 D</td>
</tr>
<tr>
<td>AC/A ratio</td>
<td>4.1 ± 2.1</td>
</tr>
</tbody>
</table>

**Case 1: Initial Visit**

- 16 year old female
  - History of dual impact concussion ~15 months prior to presentation
  - Seen by ophthalmology after injury, diagnosed with commotio retinae
  - Reports intermittent diplopia and blurry vision at near point since injury
  - Moderate to severe headaches that worsen with near point tasks
  - Ocular history: myopia corrected with glasses and contact lenses

- Convergence Insufficiency Symptom Survey (CISS)

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Score</th>
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<tbody>
<tr>
<td>Eye symptoms</td>
<td></td>
</tr>
<tr>
<td>Strabismus</td>
<td></td>
</tr>
<tr>
<td>Headache</td>
<td></td>
</tr>
<tr>
<td>Eye pain</td>
<td></td>
</tr>
<tr>
<td>Dizziness</td>
<td></td>
</tr>
<tr>
<td>Blurred vision</td>
<td></td>
</tr>
<tr>
<td>Dizziness on looking up</td>
<td></td>
</tr>
<tr>
<td>Dizziness on looking down</td>
<td></td>
</tr>
<tr>
<td>Amplitude of accommodation (push-up)</td>
<td></td>
</tr>
<tr>
<td>Dynamic retinoscopy (MEM)</td>
<td></td>
</tr>
<tr>
<td>Monocular accommodative facility</td>
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</tr>
<tr>
<td>Adults</td>
<td></td>
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</tbody>
</table>

**Case 1: Initial Visit**

- DVaC: OD: 20/15-3  OS: 20/15-1
- NVaC: OD: 20/20  OS: 20/20
- Contact Lenses
  - Acuvue 1 Day Moist 8.5/14.2/OD-5.00, OS-3.50
- Lensometry
  - OD: -5.00  OS: -4.00-0.75x035
- EOMs: FESA
- Pupils: PERRLA – APD
- Confrontation: TFFC OD, OS
- Dry Refraction
  - OD: -5.00  OS: -3.50-0.75x035
- Cylindric Refraction
  - OD: -5.25  OS: -3.50-0.75x035
- SLE: unremarkable
- IOP: 12 OD, OS
- DFE: RPE disruption superior to macula OS
Case 1: Initial Visit

**Assessment:**
1. Myopia-stable
2. Convergence Insufficiency
3. Accommodative Insufficiency

**Plan:**
1. Slightly over minus OS in glasses. Contacts are acceptable. Consider changing glasses prescription.
2&3. No subjective improvement with near or prism correction. Recommended vision therapy: Brock String, Hart Chart and +/-1.00 monocular flippers

RTC 2 weeks

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### Case 1: 2 Week Follow up

- Excellent compliance
- VT getting easier
- Can read for longer, but still gets diplopia and blur

DVA<sub>eq</sub>: 20/15 OD, OS  
CT<sub>eq</sub>: ortho, 14 XT'  
NPC<sub>eq</sub>: 20cm/30cm acc  
Step Vergence:  
DBI: x/4/2, DBO X/6/4  
NBI: 2/6/4, NBO X/6/2  
Amps: 2.5D OD, OS  
Accommodative Facility: unable to clear -2.00 OD, OS, OU  
Subjective improvement w/ stable clinical findings. Continue with Brock String, +1.00/-1.00 flipper. Add 8pd prism jump. FU 2 weeks.

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### Case 1: 4 Week Follow up

- Excellent compliance, symptoms improving
- Able to complete school work

DVA<sub>eq</sub>: 20/15, 20/20  
CT<sub>eq</sub>: ortho, 8XP'  
NPC: 5/7cm acc, 7/10cm light  
NBI: X/18/35, NBO: 20/35/25  
Amps: 5 D OD, OS  
Accommodative Facility: 11 CPM OD, 12.5 CPM OS, fails - OU  
Significant improvement in clinical signs and symptoms. Start tranaglyph, +/-1.00 flippers, 12pd prism jumps

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### Case 1: 8 Week Follow up

- Excellent compliance  
- Reports increased HA and diplopia, felt to be associated with end of school work load

DVA<sub>eq</sub>: 20/20+, 20/15  
CT<sub>eq</sub>: ortho, 8XP'  
NPC: TTN acc, 8/9cm light  
NBI: X/25/18, NBO: 20/35/25  
Amps: 5 D OD, OS  
Accommodative Facility: 12 CPM OD, 13 CPM OS  
Stable clinical findings. Continue vision therapy. +/-2.00 flippers, Lifesaver cards, 15pd prism jumps. FU 3 weeks

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### Case 1: 15 Week Follow up

- Summer vacation  
- Improved symptoms with exercises performed 2x/week

DVA<sub>eq</sub>: 20/15 OD, OS  
CT<sub>eq</sub>: ortho, 8XP'  
NPC: TTN acc, 2/4 cm light  
NBI: X/25/18, NBO: 20/35/25  
Amps: 6.25 D OD, OS  
Accommodative Facility: 11 CPM OD+OS; 5 CPM OU, slow minus +1.25 OU NVO glasses significant subjective improvement  
At 3 week FU, stability in findings with maintenance exercises, continues to wear +1.25 readers over CL
Convergence Insufficiency

- Prevalence about 5% in US school age children
- CITT Study group – Randomized controlled studies
  - Office based eye exercises more effective compared to computerized/home based eye exercises and pencil push-ups
  - Convergence Insufficiency Symptom Survey (CISS)
  - Placebo vs. Base In prism glasses.
  - Relationship of CI with academic behaviors and ADHD

Convergence Insufficiency

- Typical Symptoms
  - Headaches and eye strain with close work
  - Burning and tearing with reading
  - Intermittent blurry vision
  - Intermittent double vision
  - Sleep with reading
  - Skip lines, lose place, re-read line
  - Slow reading
  - Worsening of symptoms end of the day

Convergence Insufficiency

- Diagnostic Signs
  - Exophoria at near
  - Receded near point of convergence
  - Reduced positive fusional vergence
  - Decreased vergence facility
  - Low AC/A ratio
  - Decreased NRA
  - Accommodation – Insufficient (lag) or excess (lead)
  - Difficulty clearing plus on binocular accommodative facility

Convergence Insufficiency

- Treatment Options
  - Vision Therapy – recommended treatment
    - In-office
    - Home-based
    - Computer-based (ex. HTS)
  - Low plus glasses ~+0.75 to +1.00 if accommodative component is confirmed
  - BI prism glasses

Mild Traumatic Brain Injury and Vision

- Symptoms - attributed to the visual system and processing
  - Headache – close work
  - Light sensitivity
  - Double vision
  - Blurry vision – intermittent
  - Trouble focusing and concentrating
  - Difficulty reading or sustaining continuous reading
  - Dizziness
  - Balance
  - Vertigo
  - Motion
  - Difficulty in a crowded environment

Traumatic Brain Injury and Vision

- ~60% of mTBI patient have visual abnormalities (civilian and military)
- 50% of the brain is involved in visual information processing
- Increased vulnerability with TBI

Traumatic Brain Injury and Vision

- Common Visual Sequelae of mTBI
  - Uncorrected refractive error
  - Deficits in accommodation
  - Deficits in vergence
  - Deficits in versions – tracking
  - Light sensitivity
  - Vestibular symptoms


Case 2

- 9 year old girl
  - Headache with reading
  - Comes home with headache
  - Loses place while reading
  - Blurry vision while reading
  - Sometimes has double vision

Case 2

- Low hyperopia
- Accommodative Insufficiency
- CI/Pseudo CI

- Sudden loss of accommodation – MRI - Normal
- Did attempt exercises - Moderate improvement in accommodation amplitude – poor compliance
- Happy with near vision glasses (+1.25D)

Case 3

- 6 year old with Down Syndrome
  - Has desire to read
  - Able to sound out words
  - Frustration and regression observed

Case 3

- Prescribed glasses
  OD: +1.50 -1.00 x 160
  OS: +1.50 -1.00 x 20
  Add +1.50

- Bifocal in Down Syndrome (BIDS) study

Accommodative Insufficiency

- **Symptoms**
  - Blurry vision at near
  - Eye strain and fatigue with near work
  - Difficulty paying attention and concentrate when reading

- **Diagnostic signs**
  - Dynamic retinoscopy - Accommodative lag*
  - Low accommodative amplitude
  - Low PRA
  - Fail minus lenses with accommodative facility (monocular & binocular)

- **Treatment**
  - Reading glasses
  - Vision Therapy

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**Case 4**

- 26 year old nurse, nurse
- Referred by local optometrist

- **Symptoms**
  - Headache worsens through the day
  - Takes few seconds for letters to clear
  - Focusing difficulties
  - Blurry vision intermittently distance and near
  - Ongoing difficulties for the last 2 years

- **Intake questionnaire**
  - Excessive squinting
  - Double vision
  - Frequent tearing
  - Blurred vision
  - Light sensitivity
  - Tired eyes when reading
  - Poor peripheral vision

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**Case 4**

<table>
<thead>
<tr>
<th>DVA</th>
<th>OD: -20/60-2</th>
<th>OS: 20/30</th>
<th>OU: 20/25-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slow reading – 10 minutes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NVA</th>
<th>OD: 20/30</th>
<th>OS: 20/25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current Rx</td>
<td>OD: +0.50</td>
</tr>
</tbody>
</table>

- **Dry Refraction**
  - OD: Plano
  - OS: Plano

- **Cover Test**
  - Near 2 – 3 exophoria

**NPC**

- 9-10 cm; target blurry

**Amps**

- OD: 6.90 D
- OS: 7.41 D

**MEM**

- OD: Plano to -0.25
- OS: +1.50

- **Accommodative flippers (20/50)**
  - OD: 3 CPM
  - OS: 2 CPM

- **Difficulty clearing plus lens**

- **Cycloplegic Refraction**
  - OD: +1.00 -0.25 x 130 (20/20)
  - OS: +2.00 -0.50 x 35 (20/20-3)

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**Case 4**

- Diagnosis
  - Accommodative spasm
  - Uncorrected hyperopia with oblique astigmatism

**Rx given**

- +0.75-0.25 x 130
- +1.75-0.50 x 35

**RTC in 6 to 8 weeks**

- **Eye exercises**
  - HART chart
  - Flippers +1.00/-1.00

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**Case 4**

- Follow up visit – 3 months
- Was difficult to get used to the glasses
- Improvement in symptoms -nausea and headache
- But eventually vision got better
- “Not spasming as much as before”
- Moderate compliance with exercises – flippers “plus” side difficult to clear.

**DVA**

<table>
<thead>
<tr>
<th>OD: 20/40-2</th>
<th>OS: 20/50-2</th>
</tr>
</thead>
</table>

**MEM**

- OD: +0.75
- OS: +0.75

**Amps:**

- OD: 7.84 diopters
- OS: 7.41 diopters

**Accommodative Facility**

- OU: 2.5 cycles/min (difficulty with “+” lens)
Case 4
- Return visit 5 months later
- Reported doing much better with glasses on and off
- Without Rx does get headache

**DV Acc:**
OD: 20/25-3  
OS: 20/40

**NV Acc:**
OD: 20/25-  
OS: 20/25

**MEM**
OD: Plano  
OS: +0.50

**Accommodative Flipper (sc)**
OU: 10 CPM  
OD: 5.5 CPM  
OS: 7.5 CPM

**Amps (sc)**
OD: 7.55 D  
OS: 7.27 D  
OU: 9.30 D

Follow up in 4 months
- Sometimes feels glasses not strong enough
- Blurry vision intermittently far away and near
- Headache better – still present, not spasming.
- Compliant with glasses

**DV Acc:**
OD: 20/25  
OS: 20/20-2

**NV Acc:**
OD: 20/30  
OS: 20/25

**Over refraction**
Plano  
Plano

**MEM**
OD: Plano  
OS: Plano

**Amps**
OU: 7.69 D

**Cycloplegic Retinoscopy**
OD: +1.00 -0.25 x 135  
OS: +1.00 -0.25 x 135

Case 4
- Follow up in 4 months
- Sometimes feels glasses not strong enough
- Blurry vision intermittently far away and near
- Headache better – still present, not spasming.
- Compliant with glasses

**DV Acc:**
OD: 20/25  
OS: 20/20-2

**NV Acc:**
OD: 20/30  
OS: 20/25

**MEM**
OD: Plano  
OS: Plano

**Amps**
OU: 7.69 D

**Cycloplegic Retinoscopy**
OD: +1.00 -0.25 x 135  
OS: +1.00 -0.25 x 35

Accommodative Spasm

**Symptoms**
- Eye strain and headache with near tasks
- Intermittent blurred vision at distance

**Diagnostic signs**
- Visual acuity – fluctuating
- Dynamic retinoscopy – lead of accommodation
- Low NRA
- Esophoria at near
- Fail plus lenses with accommodative facility (monocular & binocular)

**Treatment**
- Cycloplegic refraction
- Atropine
- Exercises

Case 5: Initial Visit
- 8 yo male referred by physical therapist (PT) for eye exam due to trouble tracking, making eye contact and focusing.
  - Uses a guide for reading.
  - Being evaluated for ADHD and difficulties with working memory.

**Case 5: Initial Visit**

**DV Acc:**
20/20 OD, OS @ D+N  

**CT:** ortho D+N

**EOMS:** Full, loses fixation  
PERRLA – APD

**NPC:** TTN acc, 6/10 lite  
NBI: X/10/8, NBO: X/20/18

**Accommodative Facility:** 10cpm  
OD, 8cpm OS, slower with plus

**Amps:** Push away 10 D OD, OS

**DEM:** H 110 sec, V 80 sec, Ratio: 1.38

**Fixation:** able to maintain for 2 sec

**NSUCO:** large head movements & loss of fixation with saccades, mild head movement w/pursuits

**Cycloplegic Retinoscopy:**  
OD +0.50, OS +0.75-0.50x180  
Ocular Health Unremarkable OU

Case 5: Initial Visit
- Assessment and Plan
- Oculomotor dysfunction
  - Prescribed saccadic workbook and Eye Movement Workbook dispensed to perform daily. Also, hand-eye coordination activities.
- Follow up 1 month
Case 5: 1 month follow up

- Patient reports good compliance with therapy. Performing daily 15-20 minutes

DVA: 20/20 OD, OS
CT: ortho OD and OS
NPC: TTN accom, 6/10cm lite
Amps: 8cm (12.5 D) OD, OS
DEM: H 87 sec, V 68 sec, Ratio(H/V): 1.28
Fixation: fixates for >10 seconds

- Improvements seen. Start heart chart, saccadic workbook level 3, visual tracing, mazes. FU 4 weeks.

Oculomotor Anomalies

- Tracking difficulties
  - Reading and learning difficulties
- Symptoms
  - Skipping words
  - Skipping lines
  - Losing place
  - Re-reading lines
  - Using finger or index card to keep track of lines

- Diagnostic testing
  - Saccades
  - Pursuits
  - DEM / King-Devick test

Learning disability

- Neurodevelopmental disorder persistent life long impairment
- fMRI studies
- Language processing centers – phonological processing deficits
- Eye movement deficits, visual span, visual search, convergence, visual attention deficits
- Causality ??

- Recent literature
  - Visual attention and its impact on learning
  - fMRI studies

References