Type of strabismus and changes to fusion measures

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There is no actual or potential conflict of interest in relation to this presentation.
**Vergence system**

**Phasic**
Fast response to a prism in front of one eye (reflex fusion system driven by retinal disparity) - Eyes are realigned.

**Tonic**
Slow response which adapts to the fusional demand (vergence adaptation) reducing the load placed on the vergence system by the heterophoria.

Vergence testing

• Assessing the range of vergence provides information about the patient’s ability to maintain the binocular vision.

• Disparity vergence measurements should be used to quantify control of an underlying eye misalignment.

• In the presence of a manifest deviation the testing is performed by first compensating the angle of deviation to determine prognosis.

Vergence testing
Vergence adaptation

Abnormal vergence adaptation
- Deficit in the slow vergence mechanism

Fast fusional controller
- Sustained response must be maintained

Symptoms
- Asthenopia

Testing and clinical implications

- **Prescribing prisms**
  - Estimate the magnitude of the true phoria after dissociation.
  - Additionally use temporary stick-on fresnel prims until the real magnitude is properly accessed.

- **Surgical intervention** (avoid angle underestimation)
  - **Prism adaptation testing** is important in strabismic patients revealing latent esotropia (total deviation).
  - An **alternative method** could be sustained dissociation.

Type of deviation

- In an **exophoria** there is an increase in the fast fusional convergence while in an **esophoric deviation** there is an increase in reflex fusional divergence to attain binocular single vision.

- Convergence fusion amplitudes have been found to correlate with control of the exodeviations.

- There is a greater BO range for esos and greater BI range for exos.

Hatt et al., 2011; Kim et al., 2010; Rowe, 2010; Sreenivasan, Irving, & Bobier, 2012.
Type of deviation: unpublished data

- Five-hundred and thirty children with a mean age of 7.66±1.20 (range 6 to 14) years were included in the study.
- There were 280 females (52.8%) and 250 males (47.2%).
- The median angle of deviation was:
  - 4PD (2 to 10PD) at near fixation (n=181) and 4PD (2 to 4PD) at distance (n=20) for exophoric children
  - 6PD (2 to 10PD) at near fixation (n=22) and 4PD at distance (n=1) for esophoric children
Type of deviation: unpublished data

<table>
<thead>
<tr>
<th>Heterophoria</th>
<th>Fusional amplitudes</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Median</th>
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<tbody>
<tr>
<td>Orthophoria</td>
<td>Near PFV</td>
<td>20.48</td>
<td>4.83</td>
<td>20.00</td>
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<td></td>
<td>Distance PFV</td>
<td>13.10</td>
<td>3.22</td>
<td>12.00</td>
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<tr>
<td></td>
<td>Near NFV</td>
<td>9.57</td>
<td>1.96</td>
<td>10.00</td>
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<tr>
<td></td>
<td>Distance NFV</td>
<td>6.97</td>
<td>1.83</td>
<td>8.00</td>
</tr>
<tr>
<td>Esophoria</td>
<td>Near PFV</td>
<td>22.27</td>
<td>5.60</td>
<td>20.00</td>
</tr>
<tr>
<td></td>
<td>Distance PFV</td>
<td>14.00</td>
<td>0.00</td>
<td>14.00</td>
</tr>
<tr>
<td></td>
<td>Near NFV</td>
<td>9.64</td>
<td>2.11</td>
<td>10.00</td>
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<tr>
<td></td>
<td>Distance NFV</td>
<td>6.00</td>
<td>0.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Exophoria</td>
<td>Near PFV</td>
<td>19.54</td>
<td>5.26</td>
<td>18.00</td>
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<td>12.60</td>
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<td></td>
<td>Near NFV</td>
<td>9.96</td>
<td>2.02</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td>Distance NFV</td>
<td>7.20</td>
<td>1.20</td>
<td>8.00</td>
</tr>
</tbody>
</table>

Legend: PFV – positive fusional vergence; NFV – negative fusional vergence;

Statistically significant: exophoria-orthophoria - p=0.003; exophoria-esophoria - p=0.035
A shift towards **base-out range** was seen in esophoric children while a shift towards the base-in range was seen in exophoric children.

- This result is in accordance with Rowe’s (2010) study reporting a skewed vergence range with esophorias having a bias towards the divergent range and vice versa.

- Exophoric children also had significant **lower positive fusional vergences** for near compared with children with orthophoria and esophoria.
Type of deviation: unpublished data

- Exophorics have a significantly reduced base-out prism adaptive response when compared to orthophorics.

- Reduce convergence break points have been suggested as a maker of severity in intermittent exotropia.

- In the present study there was no significant difference in divergence amplitudes when comparing exophoric children with children with orthophoria or esophoria.

- Others studies found similar divergence amplitudes between patients with intermittent exotropia and normal subjects.

Dowley, 1990; Fu et al., 2015; Hatt et al., 2011; Liebermann et al., 2012.
## Order of vergence testing

### CONVENTIONAL PROCEDURE

Base-in measurements should be measured first to avoid *vergence adaptation* caused by base-out prism. OR

Base-out, base-up, Base-in, and basedown to prevent vergence adaptation.

(Cooper, 1992; Fray, 2013; Rosenfield et al., 1995; Von-Noorden & Campos, 2002)

### STUDIES ON VERGENCE ADAPTATION

Phorias should be measured before vergence amplitudes to avoid the shift in the lateral phoria towards the direction of the prism duction.

The base of the prism should be placed first in the *direction opposite* to that used to measure the deviation so as to increase the vergence demand.

(K. Arnoldi, 2009; Rosenfield et al., 1997)
• Smaller convergence fusion amplitudes were associated with larger angles and vice versa at near \( r_s = -0.115; p<0.008 \).

• A similar finding was done by Hatt et al. (2011), however as we used children with heterophorias with angle of deviation ≤ 10DP the strength of the correlation was lower.

• Lower fusion reserve ratios were associated with larger angles and vice versa) at distance \( r_s = -0.849; p<0.001 \) and at near \( r_s = -0.821; p<0.001 \).
Angle of deviation: unpublished data

- No correlation was found between distance fusional convergence and distance angle.
- This results are in accordance with Hatt et al. (2011).
Exophoria and fusional vergence

**EXOPHORIA**
Smaller fusion reserves are associated with larger angles and vice versa at near.

**CONVERGENCE**
Exophoric children have significant lower positive fusional vergences for near compared with children with orthophoria and esophoria.

**DIVERGENCE**
No significant difference in divergence amplitudes when comparing exophoric children with children with orthophoria or esophoria.

When convergence is stimulated an inhibition of the natural tendency to diverge as to occur, which results in a reduction of convergence peak velocity (Kim et al, 2010).
Testing and end results

Ocular dominance
• There is a slightly trend for greater base out vergence range fixing with the non-dominant eye, these effects do not constitute clinically significant impact.

Target size
• Vergence range is higher when measured with a peripheral target compared with a central target (particularly for positive fusional range).

Near versus distance
• Measurements at near versus distance fixation also have significant differences, especially in positive fusional vergence.
Protocol for testing: recommendations

Cover test

Type of deviation

Vergence measures

Ocular dominance
(Choose either eye)

Target size
(Use normative values according to target size)

Near versus distance
(Measurements should be done for both distances – 1st distance)

1st assess underlying deviation

Divergent

1st assess convergence

2nd assess divergence

Convergent

1st assess divergence

2nd assess convergence
Final considerations

• The present findings suggest that phoria as an important role within the vergence system and fusion measures should take these findings in consideration.

• Binocular vision assessment in symptomatic patients should include an assessment of vergence adaptation.

• There is no protocol for assessment of vergence (prism) adaptation or time line for duration of dissociation.

• Further studies are necessary to fully comprehend the vergence system.
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