Advanced Anatomy and Physiology of the Eye

By Diane F. Drake, LDO, ABOM, NCLEM, FNAO
Introduction

- Terminology
- Anatomy
- Refractive Errors
- Spherical Correction
- Cylindrical Correction

- Presbyopia
- Muscle Imbalances
- Unequal refractive errors
- Visualizing the Rx
Visual Angle and Minimum Visual Angle
Subtend

- To extend under or to be opposite to
- The angle which is opposite the object being observed
Minimum Detail

- The detail that must be detected on an object to positively identify or distinguish the object.
Resolution

- The ability to detect minimum detail
- The resolving power of the normal eye is a minimum visual angle of 1 minute
- The minimum visual angle of the letter is 1 minute
- The visual angle of the letter is 5 minutes
Visual Acuity

- The measure of the angle subtended by the outer limits of rays of light coming from the minimum detail of an object as they enter the eye.

- 20/20 or 6/6
Snell’s Law of Refraction

\[ n_1 \sin i = n_2 \sin r \]
The Snellen Fraction

- The distance at which the test is made divided by the distance at which the smallest letter read subtends an angle of 5 minutes
Snellen Letters
Snellen Letters

6 metre testing distance

5 minutes of arc
Minimum Angle of Resolution

MAR = 1 minute of arc

6 metre testing distance
Landolt Ring (C) and the Illiterate E
Contrast Sensitivity
Terminology

- Emmetropia
- Ametropia
- Myopia
- Hyperopia
Terminology

- Astigmatism
- Corneal astigmatism
- Lenticular astigmatism
- Regular astigmatism
- Irregular astigmatism
- Simple myopic astigmatism
- Compound myopic astigmatism
- Simple hyperopic astigmatism
- Compound hyperopic astigmatism
Terminology

- Presbyopia

- Greek
  - Presby = Old
  - Opiia = Sight
Anatomy

Aqueous humor

- Lateral rectus muscle
- Retina
- Choroid
- Sclera
- Macula lutea
- Fovea centralis
- Optic nerve
- Optic disk (blind spot)
Four Refractive Mediums of the Eye

- The cornea
- The aqueous humor
- The crystalline lens
- The vitreous humor
Anatomy

Cornea
Aqueous humor
Crystalline lens
Vitreous humor
Index of Refraction

- Cornea = 1.37
- Aqueous humor = 1.33
- Crystalline lens = 1.42
- Vitreous humor = 1.33
Dioptric Power

- **Cornea**
  - +42.00D to +45.00D
  - Performs about 80% of the refraction or bending of light rays within the eye

- **Crystalline Lens**
  - +12.00 to +15.00D
  - +20.00 D
  - Depending on textbook
Refraction

• The “bending” of light as it passes obliquely between two different refractive mediums

• A beam of light that enters a refractive medium perpendicularly is not refracted, but merely slowed down and the path of the beam is unchanged
Emmetropia
Ametropia

• Myopia
• Hyperopia or Hypermetropia
• Astigmatism
Myopia - Near Sighted - *Short Sight*
Myopia - Near Sighted - *Short Sight*
Myopia - Near Sighted - *Short Sight*
Hyperopia - Farsighted - *Long sight*
Hyperopia - Farsighted - *Long sight*
Hyperopia - Farsighted - Long sight
Astigmatism
Astigmatism
Astigmatism

- Corneal astigmatism
- Lenticular astigmatism
- Regular astigmatism
- Irregular astigmatism
- Simple myopic astigmatism
- Compound myopic astigmatism
- Simple hyperopic astigmatism
- Compound hyperopic astigmatism
- Mixed astigmatism
Corneal Astigmatism
Lenticular Astigmatism
Regular Astigmatism
Types of Regular Astigmatism

- Simple myopic astigmatism
- Compound myopic astigmatism
- Simple hyperopic astigmatism
- Compound hyperopic astigmatism
- Mixed astigmatism
Simple Myopic Astigmatism
Compound Myopic Astigmatism
Simple Hyperopic Astigmatism
Compound Hyperopic Astigmatism
Mixed Astigmatism
Irregular Astigmatism
Astigmatism
Astigmatism
Cylindrical Lenses

- Cylinder Lenses
- Toric Lenses
- Sphero-Cylindrical Lenses
- Flat and Toric Transposition
- Spherical Equivalent
- Contact Lenses
Terminology

- Presbyopia

- Greek
  - Presby = Old
  - Opia = Sight
Presbyopia

- Causes
- Treatment
  - Spectacles
  - Contact Lenses
Understanding Presbyopia

- Age-Related Vision Changes
  - As we age, our visual system undergoes major changes

- Decline of accommodation
- Senile miosis
- Loss of visual acuity
- Lowered contrast sensitivity
- Increased lighting sensitivity
- Slower speed of visual processing
## Change in the Mean Amplitude of Accommodation With Age

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Amplitude (Diopters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10.6 - 13.5</td>
</tr>
<tr>
<td>15</td>
<td>10.1 - 12.5</td>
</tr>
<tr>
<td>20</td>
<td>9.5 - 11.5</td>
</tr>
<tr>
<td>30</td>
<td>6.6 - 8.9</td>
</tr>
<tr>
<td>35</td>
<td>5.8 - 7.3</td>
</tr>
<tr>
<td>40</td>
<td>4.4 - 5.9</td>
</tr>
<tr>
<td>45</td>
<td>2.5 - 3.7</td>
</tr>
<tr>
<td>50</td>
<td>1.6 - 2.0</td>
</tr>
<tr>
<td>55</td>
<td>1.1 - 1.3</td>
</tr>
<tr>
<td>60</td>
<td>0.7 - 1.0</td>
</tr>
</tbody>
</table>

*Measured by moving the target toward the subject until first blur is reported (Borish 1970; Turner 1958)*
Corrections for Presbyopia

- Rx reading glasses
- OTC readers
- PAL's
- Segmented lenses
- Contacts *(Soft and Rigid)*
  - Mono
  - Bifocals
  - Modified

- Surgery
  - Explain limitations to your patients
- Others
Muscle Imbalances

- Terminology
- Muscles of the Eye
- Possible Corrections
The bony orbit

- Quadrilateral pyramid
- Influenced by age, trauma, as well as chronic sinus infections.
- Bed ridden, non-mobile person
- Contain the muscles of the eye
Extraocular Muscles

- **Medial rectus (MR)**—moves the eye toward the nose
- **External rectus (ER)**—moves the eye away from the nose
- **Superior rectus (SR)**—primarily moves the eye upward and secondarily rotates the top of the eye toward the nose
- **Inferior rectus (IR)**—primarily moves the eye downward and secondarily rotates the top of the eye away from the nose
- **Superior oblique (SO)**—primarily rotates the top of the eye toward the nose and secondarily moves the eye downward
- **Inferior oblique (IO)**—primarily rotates the top of the eye away from the nose and secondarily moves the eye upward
Extraocular Muscles

- **Superior Rectus**
  - Moves the eye up
- **Superior Oblique**
  - Rotates the eye so that the top moves toward nose
- **Medial Rectus**
  - Moves eye toward nose
- **Lateral Rectus**
  - Moves eye away from nose
- **Inferior Rectus**
  - Moves the eye down
- **Inferior Oblique**
  - Rotates the eye so that the top of eye moves away from nose
Muscle Imbalances - Terminology

- Eso-
- Exo-
- Hyper-
- Hypo-
- -phoria
- -tropia
Muscle Imbalances - Terminology

- Tonicity
- Fusion
- Diplopia
Muscle Imbalances - Terminology

- Orthophoria
- Heterotropia
- Strabismus - Can lead to Lazy eye or Amblyopia
Treatment

- Glasses
- Patching
- Surgery
- Vision Therapy
Esotropia
(convergent squint) Eye turned in Cross-eyed Boss-eyed
Exotropia
(divergent squint) Eye turned out Wall eyes
Hypertropia (vertical) Eye turned up
Hypotropia (vertical) Eye turned down
Anisometropia

• “unequal measure”
• The condition when the two eyes require a different degree of correction (1.00 or more) but the same kind of correcting lens (+ or -)
• The condition may cause vertical prism imbalance at near or cause a difference in the retinal image sizes between the two eyes
Anisometropia

- Example Rx:
  - OD  -7.00 D. sphere
  - OS  -3.00 D. sphere

- Example Rx:
  - OD  +7.25 sphere
  - OS  +5.25 sphere
Antimetropia

- “opposite measure”
- The condition when the two eyes require opposite kinds of corrective lenses (+ or -)
- The condition may cause vertical prism imbalance at near or cause a difference in the retinal image sizes between the two eyes
Antimetropia

- Example Rx:
  OD  +1.75 sphere
  OS  -1.00 sphere

- Example Rx:
  OD  -2.25 sphere
  OS  +1.50 sphere
Aniseikonia

- “unequal images”
- Anisometropia or antimetropia may result in the condition whereby two unequal images are sent by the eyes to the brain
- More prevalent due to refractive surgeries

- Meridional Aniseikonia
  - Normal or less aniseikonia in one meridian and more in another due to high astigmatism in that meridian
Iseikonic lenses

- A lens or pair of lenses used to correct aniseikonia
- The following variables are used:
  - Base curve
  - Thickness
  - Vertex distance
  - Index of refraction
Analyzing and Interpreting the Rx

- Concave Lenses
- Convex Lenses
- Contact Lenses
Visualization of Rx

- What we see
- What the patient sees
Your Prescription

<table>
<thead>
<tr>
<th></th>
<th>Sphere</th>
<th>Cylinder</th>
<th>Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD</td>
<td>-2.25</td>
<td>-1.50</td>
<td>180</td>
</tr>
<tr>
<td>OS</td>
<td>+3.75</td>
<td>+1.50</td>
<td>090</td>
</tr>
</tbody>
</table>

ADD OU +2.25
Conclusion

Thank you