**Advanced Anatomy and Physiology of the Eye**

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**Introduction**

- Terminology
- Anatomy
- Refractive Errors
- Spherical Correction
- Cylindrical Correction
- Presbyopia
- Muscle Imbalances
- Unequal refractive errors
- Visualizing the Rx

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**Visual Angle and Minimum Visual Angle**

![Visual Angle and Minimum Visual Angle](image)

**Subtend**

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

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**Minimum Detail**

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

![Minimum Detail](image)

**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

Minimum Angle of Resolution

MAR = 1 minute of arc
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
  • Opia = Sight

Anatomy

Four Refractive Mediums of the Eye

• The cornea
• The aqueous humor
• The crystalline lens
• The vitreous humor

Index of Refraction

• Cornea = 1.37
• Aqueous humor = 1.33
• Crystalline lens = 1.42
• Vitreous humor = 1.33

Diopteric 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

Myopia - Near Sighted - Short Sight

Myopia - Near Sighted - Short Sight
Hyperopia - Farsighted - Long sight

Hyperopia - Farsighted - Long sight

Hyperopia - Farsighted - Long sight

Hyperopia - Farsighted - Long sight

Astigmatism

- Corneal astigmatism
- Lenticular astigmatism
- Regular astigmatism
- Irregular astigmatism

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>
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<tbody>
<tr>
<td>10</td>
<td>10.0 - 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>
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<tr>
<td>30</td>
<td>6.6 - 8.9</td>
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<tr>
<td>35</td>
<td>5.8 - 7.3</td>
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<tr>
<td>40</td>
<td>4.4 - 5.9</td>
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<tr>
<td>45</td>
<td>3.5 - 3.7</td>
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<tr>
<td>50</td>
<td>1.6 - 2.0</td>
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<tr>
<td>55</td>
<td>1.3 - 1.5</td>
</tr>
<tr>
<td>60</td>
<td>0.7 - 1.0</td>
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</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

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

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
- 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

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

Example Rx:
- OD +1.25 sphere
- OS +3.25 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

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<th>Sphere</th>
<th>Cylinder</th>
<th>Axis</th>
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<td>180</td>
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<tr>
<td>OS</td>
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Conclusion

Thank you