Ocular Motility Fundamentals

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Financial Disclosures and Recognition

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American Academy of Ophthalmology

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Thank you!

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L2: **Ocular Motility Fundamentals** (Beginner)
(Prerequisite to workshop 4)

Learning Objectives:

- Attendees will be able to properly perform several types of ocular motility and alignment tests including:
  - Cover-uncover testing and cross-cover testing
  - Maddox Rod and Worth 4-Dot testing
  - Versions and Ductions
- Attendees will be able to describe how to identify and document findings of ocular motility and alignment testing, such as:
  - Tropias and Phorias
  - Common deviations that are found during a routine work-up

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Ocular Motility: COT: 6% COMT: 12%

- **Functions**
- **Anomalies**
- **Ductions and Versions**
- **Cover tests**
- **Stereoacuity**
- **Nystagmus**

- **Near point convergence**
- **Near point accommodation**
- **Convergence Training**
- **Fusional convergence amplitudes**
- **Strabismus with prisms**
- **Worth 4-Dot test**
- **Maddox rod**
- **Krimsky**
- **Amblyopia therapy**

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Components of Double Vision or Strabismus Work-up

Documenting Relevant History and Ocular Motility Test Results

History

- Gather details about double vision
- Appearance of an eye turn that the patient or others notice
- Timing, triggers (fatigue), worse in certain directions of gaze
- Binocular vs monocular
- Orientation of double images, number of images, distance/near/both
- Associated signs and symptoms, headaches
- Previous treatment

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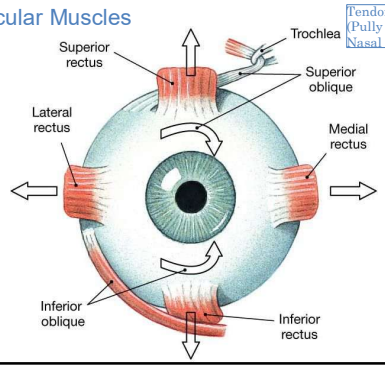
Six Extraocular Muscles



Frontal View
Right Eye

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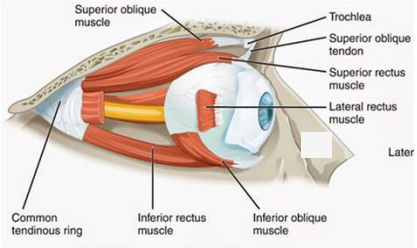
Eye Muscles



Lateral View of the Right Eye

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Muscle Functions & Innervating Cranial Nerves

Muscle	Primary Function	Secondary Function	Tertiary Function	Innervating Nerve
Medial Rectus	Nasal (Adduction)	None	None	CN III (Oculomotor Nerve)
Lateral Rectus	Temporal (Abduction)	None	None	CN VI (Abducens Nerve)
Superior Rectus	Upward (Elevation)	Incyclotorsion	Adduction	CN III (Oculomotor Nerve)
Inferior Rectus	Downward (Depression)	Excyclotorsion	Adduction	CN III (Oculomotor Nerve)
Superior Oblique	Out/Down (Incyclotorsion)	Depression	Abduction	CN IV (Trochlear Nerve)
Inferior Oblique	Out/Up (Excyclotorsion)	Elevation	Abduction	CN III (Oculomotor Nerve)

LR6, SO4, All the rest are 3

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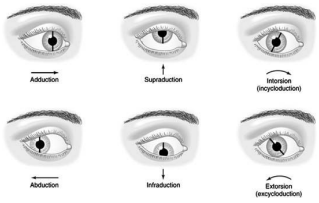
Ductions

Range of movement of **one eye**, independent from the other eye.

- **Ad**duction: towards the nose
- **Ab**duction: towards the ear
- **Supra**duction: Up
- **Infra**duction: Down
- **Incyclo**duction: Rotate in
- **Excyclo**duction: Rotate out



Right Eye

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Versions

Both eyes moving in the same direction

- **Dextro**version (both eyes to the right, as in picture below)
- **Levo**version (to the left)
- **Supra**version (upwards)
- **Infra**version (downwards)

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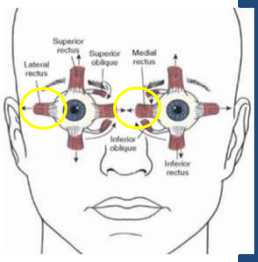
Herings' Law of Equal Innervation

Innervations to one extraocular muscle to contract generates an equal innervations to contract its **yoke muscle** (muscle performing same function in the other eye)

Tip to remember: (Herring is a fish, fish lay eggs, eggs have yolks/yokes)

Ex. Right lateral rectus
Left medial rectus



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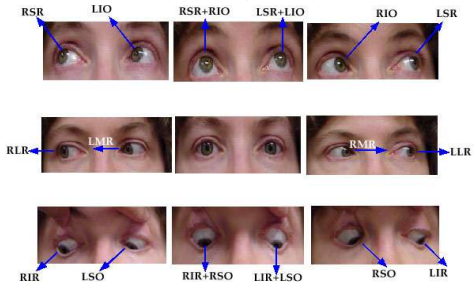
Yoke Muscles

Paired muscles of each eye moving both eyes in the same direction



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Basics of Misalignment

EOM: Extraocular Muscles/Motility

Orthotropia/Orthophoria: Eyes are aligned

Strabismus: Eye misalignment, muscle imbalance, fovea of each eye are not focused on the same object

Brain perceives two images, cannot fuse them, resulting in double vision also known as **diplopia**

Call to Action:

If a patient complains about new onset of double vision this needs noted in their chart. Ask the patient relevant HPI questions and EOM tests should be performed.

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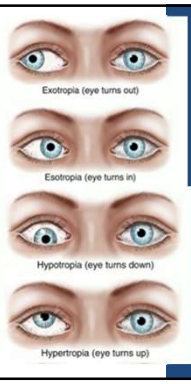
Deviations



Ortho- straight, no deviation

Exo- outward deviation (X, XT)

Eso- inward deviation (E, ET)

Hypo- downward deviation

Hyper- upward deviation (H, HT)

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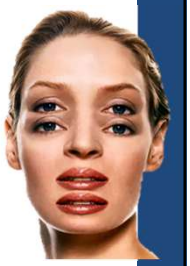
Diplopia

Diplopia = Double vision



Binocular Diplopia: See double with both eyes open

- Related to ocular misalignment
- Each eye has single vision if opposite eye covered

Monocular Diplopia: See double with one eye open

- Usually NOT related to ocular misalignment
- Possibly caused by uncorrected refractive error, astigmatism, corneal irregularities, cataract, macular changes

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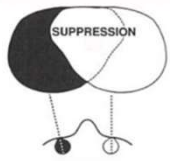
Amblyopia and Suppression

Amblyopia or lazy eye:

- The brain suppresses the vision of the weaker eye to avoid double vision.
- Strabismus (as well as anisometropia, ocular medial opacities, etc.) may lead to amblyopia
- Eventually making it uncorrectable even with refractive correction in place.

The layman's term "lazy eye" may be in reference to the strabismus (eye turn) or amblyopia (eye with weaker vision).



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Amblyopia Treatment and Prevention

Get the Weak Eye to Work

- Patching or Dilation of the "good eye"
- Muscle Therapy
- Strabismus Surgery
- Congenital Cataract Surgery
- Corneal Surgery

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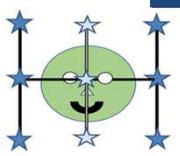
Motility Testing

- The patient is seated at arm's length (~3Ft.) from the examiner, at **equal eye level.**
- Examiner holds an appropriate fixation target halfway between the patient and examiner. The target should be held at eye level to start.
- Ask the patient to follow the target by moving their eyes only, keeping their head still as the target is moved slowly and smoothly in a Double-H pattern. (See image). The gaze is directed 30 to 40 degrees in each direction, so that the whites of the eyes are no longer visible on one side.



Remember to push in each direction.

- Also check convergence at the end by moving in towards patient's nose.
- Document the results

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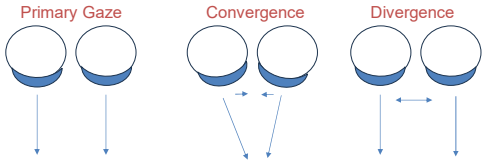
Vergences

Vergence: Eyes are both either adducting or abducting

Convergence: inward movement of both eyes toward each other, usually, to maintain single binocular vision as an object approaches

Divergence: Outward (away from each other) eye rotation, usually, to maintain single binocular vision.



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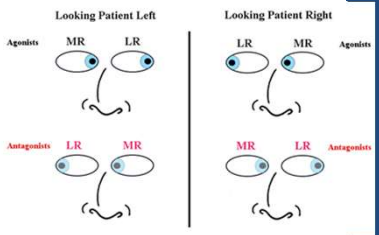
Terms to know…

Agonist: Extraocular muscle primarily responsible for moving the eye into the desired position

Antagonist: extraocular muscle whose action opposes that of the contracting muscle that moves the eye



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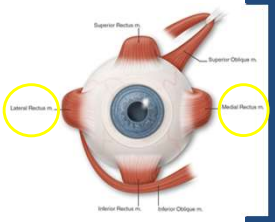
Terms to know…

Sherrington's Law: As one extraocular muscle receives an impulse from the brain to contract, its opposing muscle (direct antagonist) in the same eye receives an impulse to relax.

Tip to remember: the eye muscles have to "share"… give and take

Ex. The medial rectus contracts, so the lateral muscle needs to relax



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Terms to Know…
Nystagmus

- Involuntary rapid eye movement
- Can be lateral, vertical, or mixed
- Occlusion of one eye will make it worse
- VA is better when measured binocularly (both eyes open)

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EOM Testing

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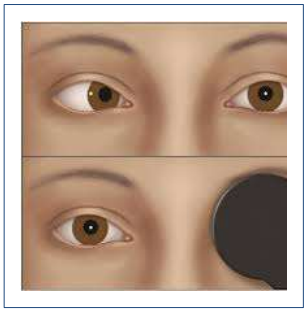

Cover Testing

- Cover- Uncover Tests, OD then OS: **Tropias**
- Cross-Cover Tests, both eyes: **Phorias**

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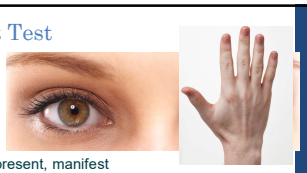
Cover-Uncover Alignment Test

Identify Tropias



- **Tropia**: A misalignment that is always present, manifest
- The deviation is classified by the direction of the misalignment
- **Cover-Uncover test:**
  - Have the patient fixate on a distance target to avoid convergence that occurs with near fixation
  - Cover and uncover one eye at a time, about 3 times,
  - Observe the eye not being covered for any movement
  - The eye will move to fixate if there is a deviation

NOTE: Must perform Cover-Uncover BEFORE Cross-Cover Testing

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Cross-Cover Alignment Test

Identify Phorias

- **Phoria**: A misalignment that appears after "breaking fusion"
- May have to cross-cover multiple times before witnessing it
- The deviation is classified by the direction of the misalignment; both eyes will move to pick up fixation
- **Cross-Cover Test:**
  - Continue to fixate on a distance target
  - Cover one eye at a time, swing back and forth
  - Observing the eye not being covered
  - Deviation is where the movement

NOTE: Tropias will turn into Phorias.

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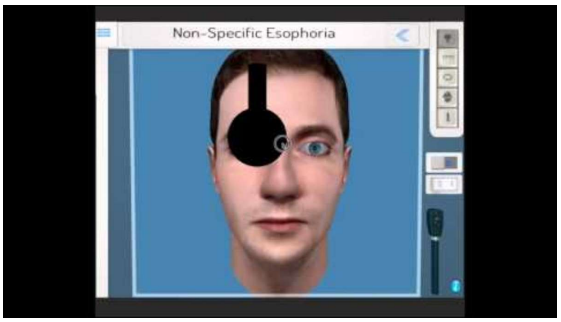
Cover Tests



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Terms to know…

Stereopsis / Stereoacuity

- Visual blending of two similar (not identical) images, one falling on each retina, into one, with visual perception of solidity and depth
- "Depth Perception"
- 3-D vision

Stereo Fly Test

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Stereopsis

Titmus Stereo Fly test

Consists of various vectograms

- One with a stereoscopic pattern representing a housefly
  - Fly: (Results saw in 3-D Y/N?)
- The other vectograms of the test provide finer tests for stereoscopic acuity
  - Circles (Keep guessing until miss 2 answers; Results: #/9)
  - Animals (Results: #/3)

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Worth 4-Dot Test

Worth 4-Dot test is one simple clinical test mainly used for assessing a patient's degree of binocular vision.

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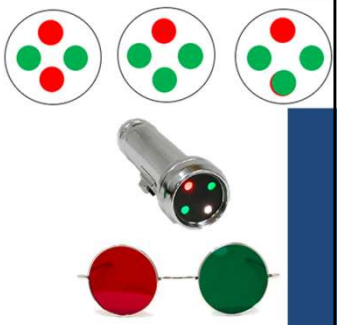
Worth 4 Dot Test

The patient sees **four dots**.

- **Normal binocular** response with no manifest deviation
- If the patient sees 2 red dots and 2 green dots, they are **right** eye dominant
- If the patient sees 1 red dot and 3 green dots, they are **left** eye dominant
- If the patient sees 1 red dot, 2 green dots, and the 4th dot fluctuates between red and green, there is NOT a strong dominance



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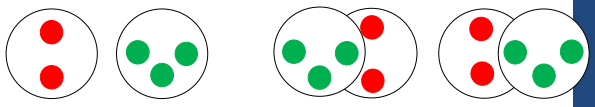
Worth 4 Dot Test

What if the patient sees more or less than 4 Dots?

- The patient only sees two red dots: Suppression of left eye.
- The patient only sees three green dots: Suppression of right eye.
- The patient sees five dots: There is binocular vision but a misalignment
  - 2 red dots appear to the right of 3 green dots: **Esotropia**
  - 2 red dots appear to the left of the 3 green dots: **Exotropia**



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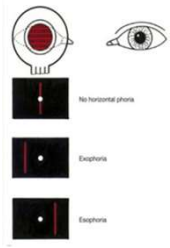
Maddox Rod

The **Maddox rod** test can be used to subjectively detect and measure a horizontal or vertical strabismus for near and distance.



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Maddox Rod Results

Red Lens over Right Eye

A) Right Esotropia
B) Right Exotropia

C) Right Hypo-deviation
D) Right Hyper-deviation

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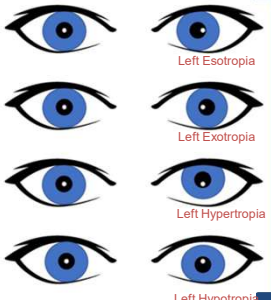
Hirschberg Test

Compare the Corneal Reflexes

- Detects presence or absence of strabismus by shining a light into the eyes then noting the position of the reflex of light
- Normal light reflex falls centrally on both corneas
- In a misaligned eye; the reflex will not be located on the central cornea



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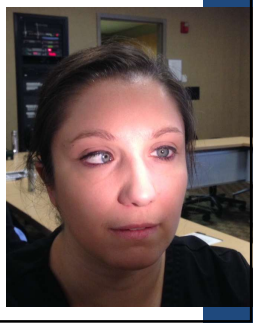
Hirschberg Test- Estimation of Prism Power Needed

Right Esotropia

For Reference, remember that:

- 1mm = 15 Prism Diopters (Δ)
- Cornea about 12mm (average)
- Pupil in bright light: 3-5mm
- This example: Cornea reflex inside edge of iris, about 4 mm (from center) so about 60 Δ



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Strabismus vs. Pseudostrabismus

- The false appearance of crossed eyes
- Generally, occurs in infants and toddlers whose facial features are not fully developed; the bridge of their nose is wide and flat

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Krimsky Test

- Like the Hirschberg Test, but introducing enough prism power to recenter corneal reflex and correct the ocular deviation

Add a little bit of prism- starting to correct misalignment

Add prism until fully corrected

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Prism in Glasses

- Prism refracts light a bit differently.
- Used to correct eye turns (strabismus) to reduce or eliminate double vision.
- Prism can be ground into the glasses or be temporary in a Fresnel Prism (sticker)

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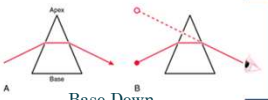
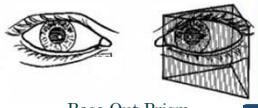
Prism Correction

- Prisms have an apex (the "point") and a base (the "fat part").
- The apex points towards the deviation.
- The base is points to the direction the eye needs to move to be in "normal" position.
- The more the eye is turned, the greater the prism power required to correct the deviation.



Base Down Prism



Base Out Prism

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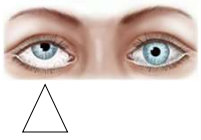
Base Down Prism



Apex of prism points toward the deviation. Forcing alignment towards the **base.**

- **Hypertropia or Hyperphoria**

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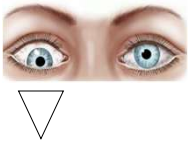
Base Up Prism



Apex of prism points toward the deviation. Forcing alignment towards the **base.**

- **Hypotropia or Hypophoria**

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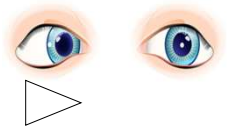
Base Out Prism



Apex of prism points toward the deviation. Forcing alignment towards the **base.**

- **Esotropia or Esophoria**

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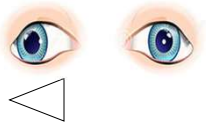
Base In Prism



Apex of prism points toward the deviation. Forcing alignment towards the **base.**

- **Exotropia or Exophoria**

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Advanced EOM Tests

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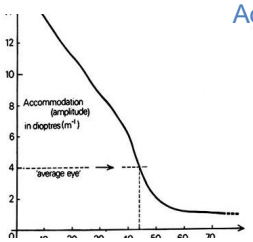
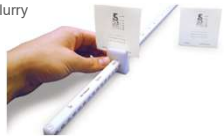
Near Point of Accommodation (NPA)



This test measures the distance from your eyes to the near card where you can still be seen clearly

Slowly move near vision card closer to the eye until the letters become blurry

Measure the distance at which the letters became blurry



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Near Point of Convergence (NPC)

- This test measures the distance from your eyes to where both eyes can focus without double vision
- Record in mm (or to the nose)
- Normal = ≤ 7mm

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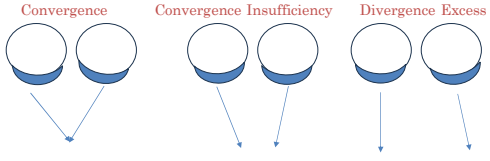
Convergence Abnormalities

Convergence Insufficiency: Inability to adequately converge enough to see and fuse image at near point, weak medial rectus

Divergence Excess: Exo-deviation causes outward positioning of one or both eyes, weak medial rectus and/or overacting lateral rectus



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Fusional Convergence Amplitudes

- Eliminates bitemporal retinal image disparity and controls an exophoria.
- Measured using an amblyoscope, rotary prism, or bar prism
  - Prism power is gradually increased until diplopia occurs
- Need to control accommodation during testing
- Can improve fusional convergence with orthoptic exercises (pencil push-ups)

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Convergence Training for Convergence Insufficiency

Track a Near Target during Convergence

- Strengthens patient's ability to converge
- "Pencil Push-ups", repeat until able to keep single image even at nose


Dr Rupa Wond Pencil Push-up Exercises: https://youtu.be/Hw4WzcnWptw

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Accommodative Esotropia

Esotropia, especially when focusing on an accommodative target.


Non-Accommodative Target

Accommodative Target

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Accommodative Convergence/Accommodation (AC/A) Ratio

- Ratio of **Accommodative Convergence to Accommodation**
  - AC = convergence caused by accommodation (Prism diopters)
  - Accommodation = natural lens accommodation, "reg" diopters
- If "average" it will be ≈ PD in cm
  - Adults 6:1
  - Children 5:1
- Importance is the difference between Distance/Near deviations when not normal
  - What do we do to FIX it? Glasses (hyperopia, bifocals), strabismus surgery

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Are Your Eyes Crossing yet?

Any questions?

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Discussion and Q&A

Who is attending a motility workshop today?

Amy Jost, MEd, COMT, CCRC
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EOM Quiz

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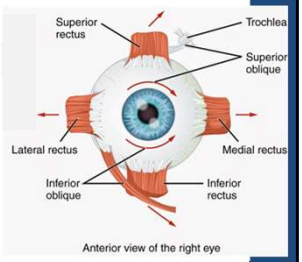
Q1. Which two muscles elevate the eye?

B. Superior Rectus, Inferior Oblique



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Q2. Which principle describes that, for one muscle to work the antagonist muscle in the same eye must relax?

D. Sherrington's Law

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Q3. Which cranial nerve innervates the Superior Oblique muscle?

B. Trochlear nerve

58

Q4. The Oculomotor Nerve (CN3) innervates this muscle that adducts the eye.

D. Medial Rectus

59

Q5. If a patient walks in and it looks like their Right eye is turned out, you could label this as a _____.

C. RXT

60

Q6. The Oblique Muscles both create ____ and ____ movements.

A. Cyclotorsional, Abduction

61

Q7. Ductions are the assessment of _____.

C. One eye's movement, isolated from the other eye

62

Q8. Convergence is when both eyes _____.

A. Adduct

63

Q9. Cross-Cover tests reveal _____.

A. Phorias

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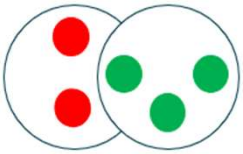
Q10. If during the Worth 4-Dot Test, your patient describes 5 dots that look like this, you know there is a/an _____ deviation.

B. Exo-



The Red Lens is over the right eye

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Answer Key

1. B
2. D
3. B
4. D
5. C
6. A
7. C
8. A
9. A
10. B

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