EXTRAOCULAR MOTILITY

ALLIED OPHTHALMIC TRAINING PROGRAM

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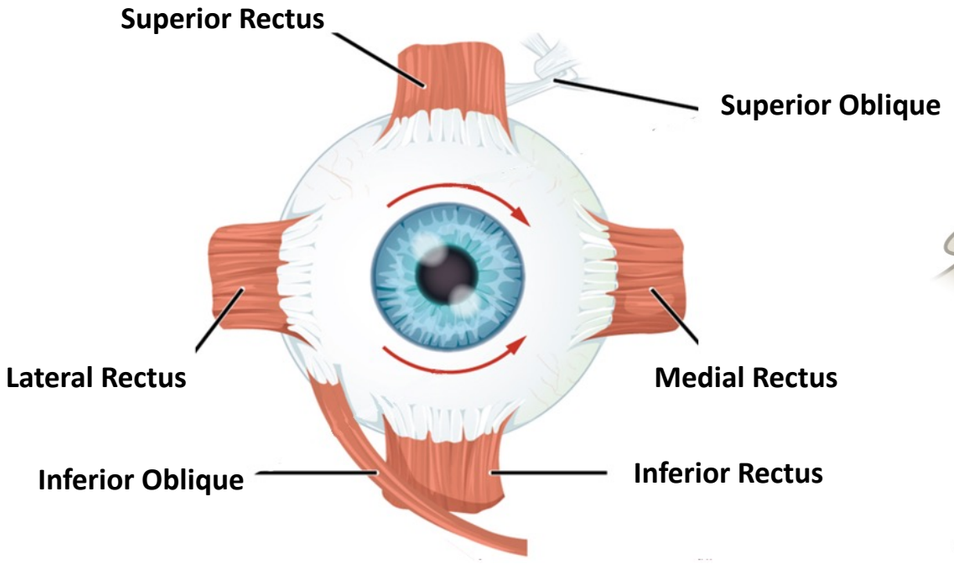
LEARNING OBJECTIVES

After this learning module, you will be able to answer the following questions:

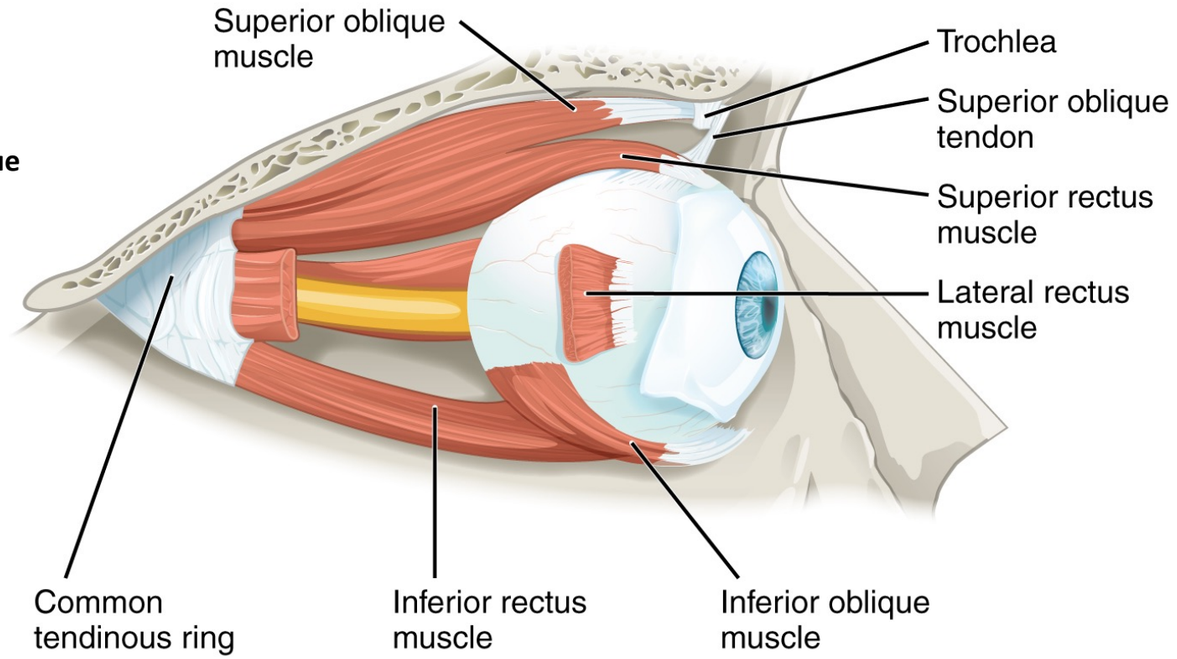
1. What are the extraocular muscles (EOMs) of the eye?
2. Which nerves innervate the EOMs?
3. What are the actions of the EOMs?
4. How are the extraocular movements of both eyes coordinated?
5. What are the 6 cardinal positions of gaze?
6. How do you evaluate and document extraocular motility?
7. What signs and symptoms can be caused by abnormalities in extraocular motility?
8. What extraocular motility abnormalities can occur from head or facial trauma?
9. What is the most common cranial nerve palsy that affects the eyes?

WHAT ARE THE EXTRAOCULAR MUSCLES (EOMS)?

Extraocular muscles are muscles that are attached to the outside of each globe (eyeball) that move and rotate the eye to help us see in different directions.



Anterior view of the right Eye



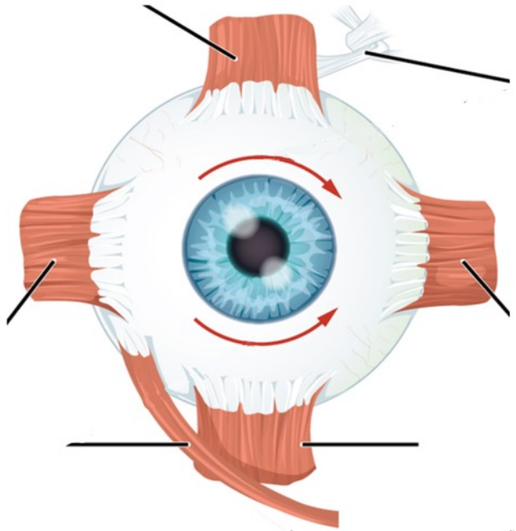
Lateral view of the right eye

[Source: modified from https://commons.wikimedia.org/wiki/File:1412_Extraocular_Muscles.jpg]

THE DIFFERENT EXTRAOCULAR MUSCLES (EOMS)

There are *6* EOMs on *each* eye that control eye movement.

6 EOMs x *2 Eyes* = *12 EOMs* that work together to help each person see in all directions!



RIGHT EYE

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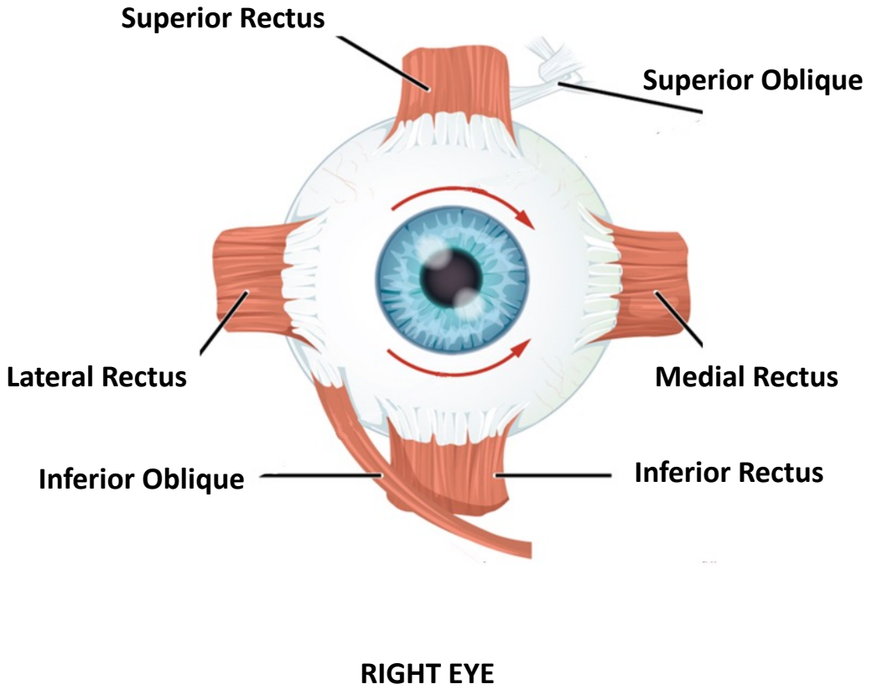

RIGHT EYE

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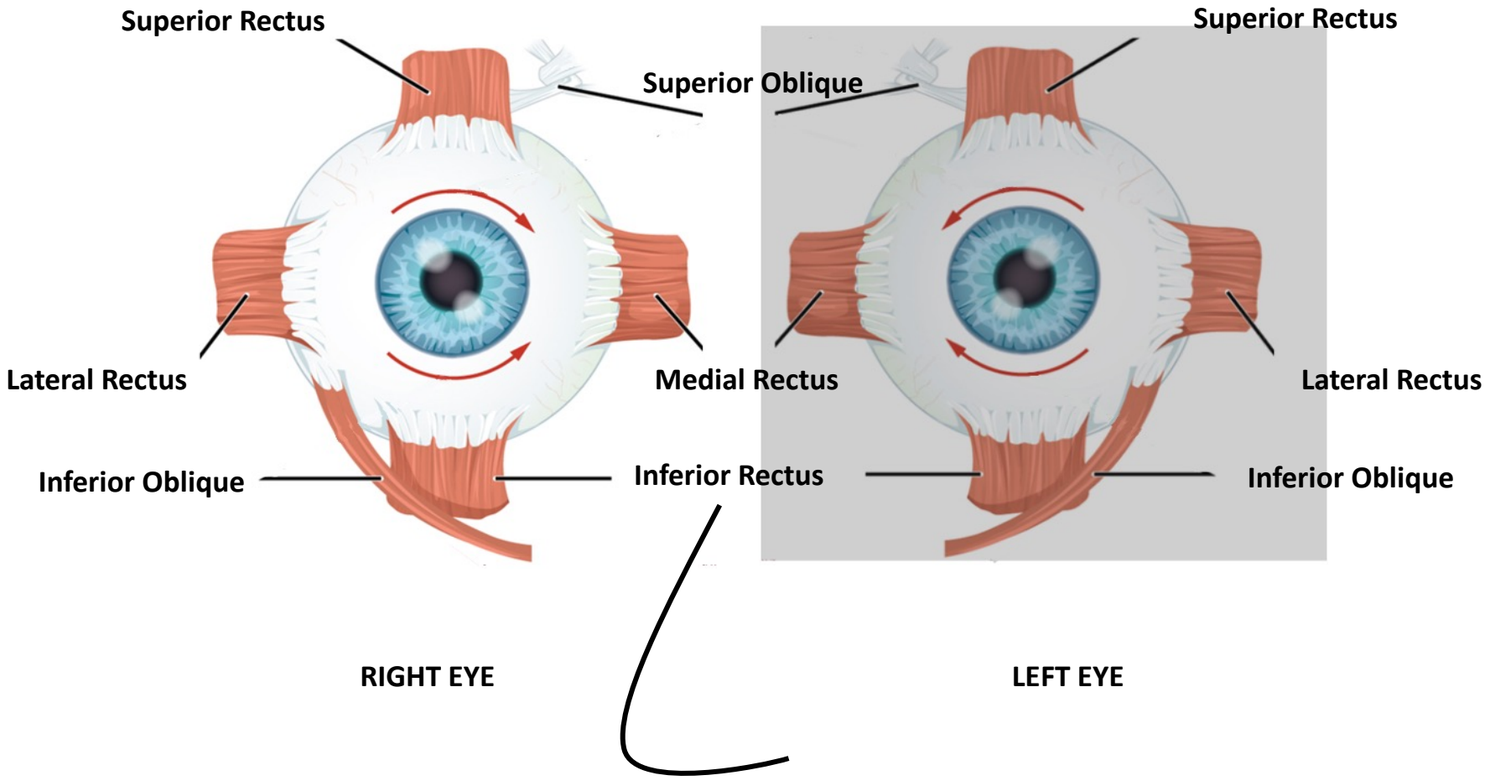

[Source: modified from https://commons.wikimedia.org/wiki/File:1412_Extraocular_Muscles.jpg]

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TEST YOUR KNOWLEDGE!

The extraocular muscles are all innervated by one nerve.

True or False?

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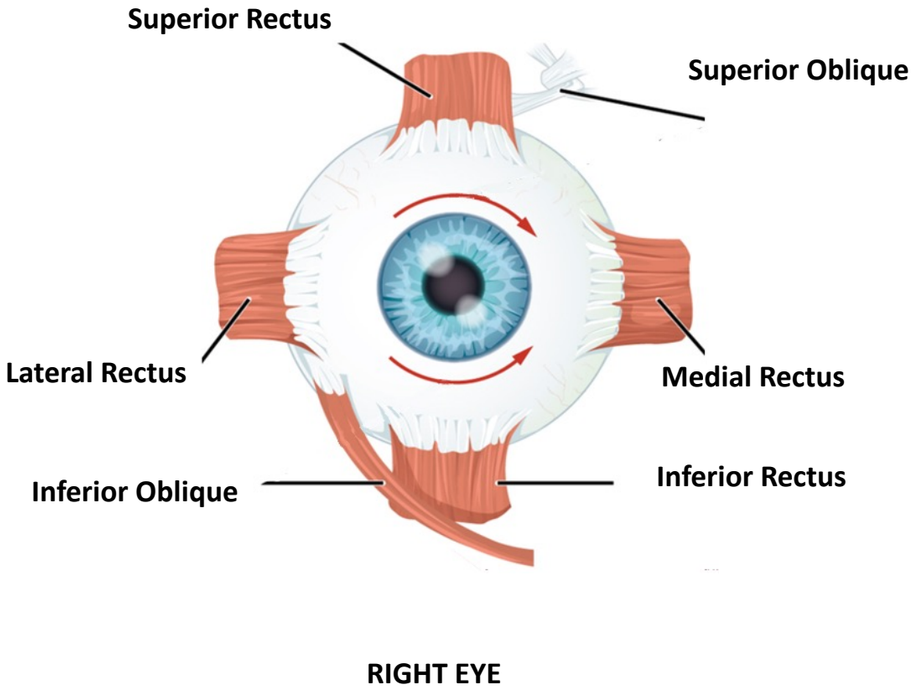
True or False?

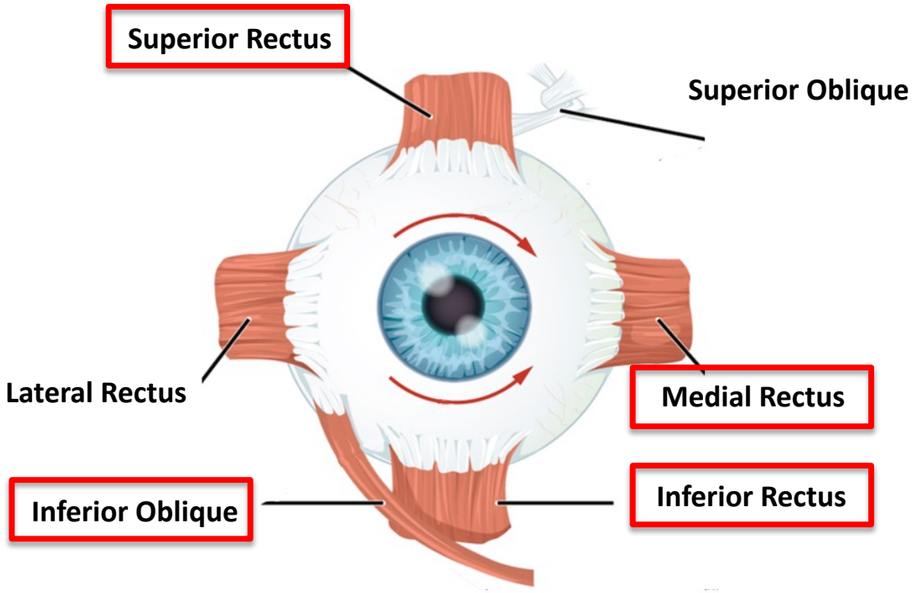
THE DIFFERENT EXTRAOCULAR MUSCLES (EOMS)



The EOMs are innervated by three different cranial nerves.

[Source: modified from https://commons.wikimedia.org/wiki/File:1412_Extraocular_Muscles.jpg]

THE DIFFERENT EXTRAOCULAR MUSCLES (EOMS)



RIGHT EYE

The EOMs are innervated by three different cranial nerves.

innervated by
Cranial Nerve 3

- Superior Rectus (SR)
- Medial Rectus (MR)
- Inferior Rectus (IR)
- Inferior Oblique (IO)

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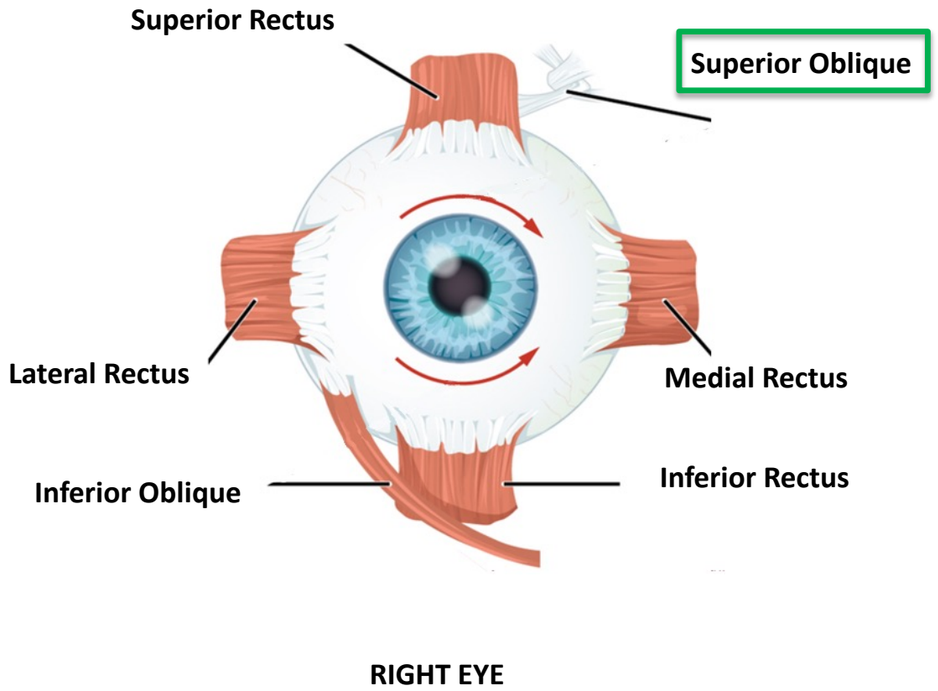

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innervated by
Cranial Nerve 4

- Superior Oblique (SO)

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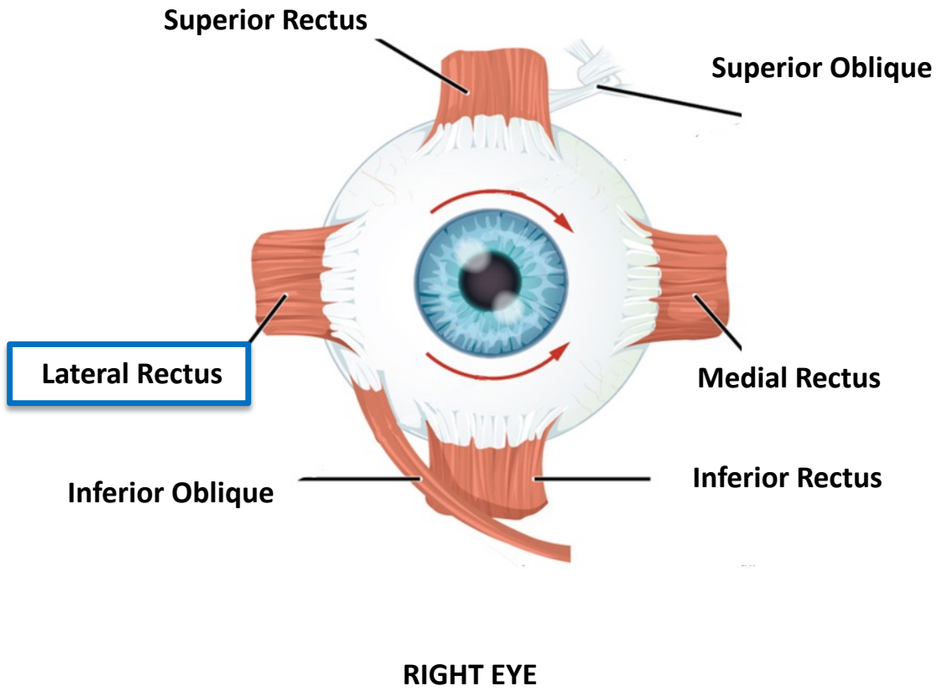
THE DIFFERENT EXTRAOCULAR MUSCLES (EOMS)



The EOMs are innervated by three different cranial nerves.

innervated by ***Cranial Nerve 3***
- Superior Rectus (SR)
- Medial Rectus (MR)
- Inferior Rectus (IR)
- Inferior Oblique (IO)

innervated by ***Cranial Nerve 4***
- Superior Oblique (SO)

innervated by ***Cranial Nerve 6***
- Lateral Rectus (LR)

[Source: modified from https://commons.wikimedia.org/wiki/File:1412_Extraocular_Muscles.jpg]

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TYPES OF EXTRAOCULAR MUSCLE ACTIONS

- Elevation: an upward movement of the eye
- Depression: a downward movement of the eye
- Adduction: an inward/medial movement of the eye (towards the nose)
- Abduction: an outward/lateral movement of the eye (towards the ear)
- Incyclotorsion/Intorsion: an inward (nasal) rotation of the eye
- Excyclotorsion/Extorsion: an outward (temporal) rotation of the eye

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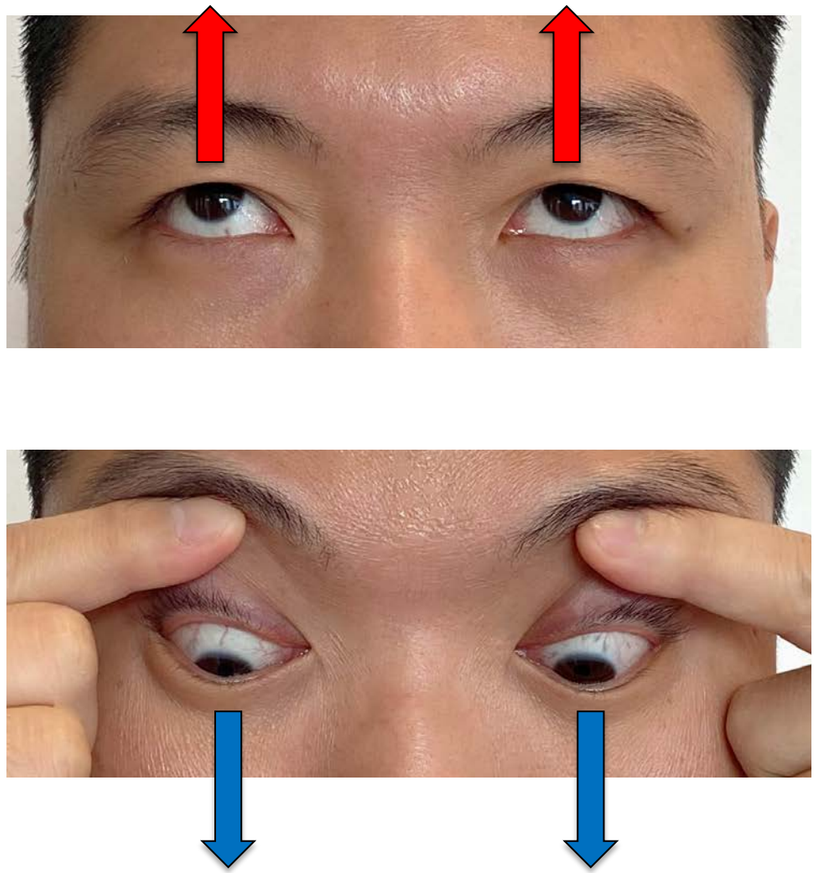

[Source: Sophia Fang, MD]

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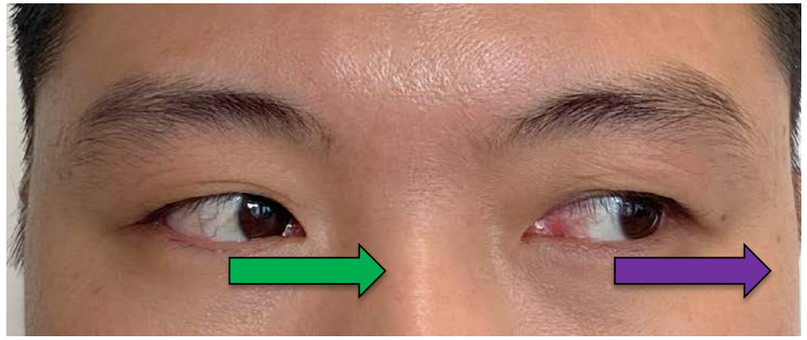

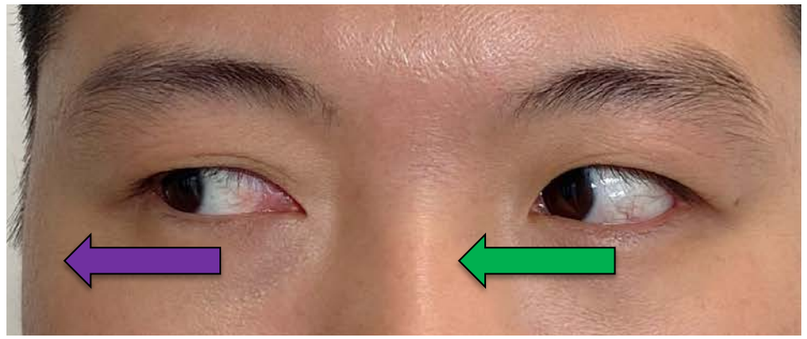

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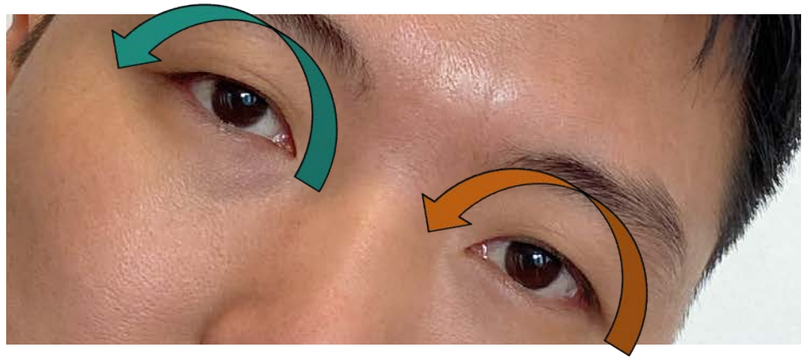
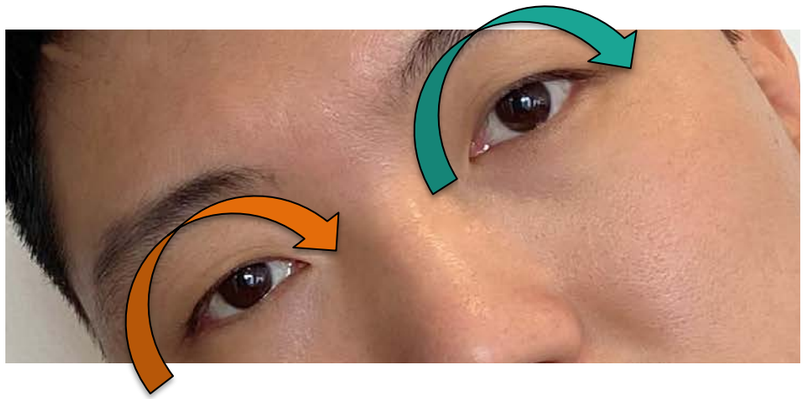
When we tilt (or rotate) our head to one side, our eyes need to rotate in the opposite direction to keep the world we see upright!





[Source: Sophia Fang, MD]

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THE ACTIONS OF EACH EXTRAOCULAR MUSCLE

While some extraocular muscles have only one action, others have multiple actions, which can be classified into primary, secondary, and tertiary functions.

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THE ACTIONS OF EACH EXTRAOCULAR MUSCLE

Extraocular Muscle	Primary Action	Secondary Action	Tertiary Action
Medial Rectus (MR)	Adduction	-	-
Lateral Rectus (LR)	Abduction	-	-
Superior Rectus (SR)	Elevation	Incyclotorsion	Adduction
Inferior Rectus (IR)	Depression	Excyclotorsion	Adduction
Superior Oblique (SO)	Incyclotorsion	Depression	Abduction
Inferior Oblique (IO)	Excyclotorsion	Elevation	Abduction

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THE ACTIONS OF EACH EXTRAOCULAR MUSCLE

Observation 1: the medial and lateral rectus muscles only have one primary action.

Extraocular Muscle	Primary Action	Secondary Action	Tertiary Action
Medial Rectus (MR)	Adduction	-	-
Lateral Rectus (LR)	Abduction	-	-
Superior Rectus (SR)	Elevation	Incyclotorsion	Adduction
Inferior Rectus (IR)	Depression	Excyclotorsion	Adduction
Superior Oblique (SO)	Incyclotorsion	Depression	Abduction
Inferior Oblique (IO)	Excyclotorsion	Elevation	Abduction

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THE ACTIONS OF EACH EXTRAOCULAR MUSCLE

Observation 2: the medial rectus muscle is the primary adductor (inward/medial movement of the eye towards the nose)

Extraocular Muscle	Primary Action	Secondary Action	Tertiary Action
Medial Rectus (MR)	Adduction	-	-
Lateral Rectus (LR)	Abduction	-	-
Superior Rectus (SR)	Elevation	Incyclotorsion	Adduction
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Superior Oblique (SO)	Incyclotorsion	Depression	Abduction
Inferior Oblique (IO)	Excyclotorsion	Elevation	Abduction

Observation 3: the lateral rectus is the primary *abductor* (outward/lateral movement of the eye towards the ear)

THE ACTIONS OF EACH EXTRAOCULAR MUSCLE

Observation 4: there are two muscles responsible for *elevating* the eye/moving the eye *upward.*

Extraocular Muscle	Primary Action	Secondary Action	Tertiary Action
Medial Rectus (MR)	Adduction	-	-
Lateral Rectus (LR)	Abduction	-	-
Superior Rectus (SR)	Elevation	Incyclotorsion	Adduction
Inferior Rectus (IR)	Depression	Excyclotorsion	Adduction
Superior Oblique (SO)	Incyclotorsion	Depression	Abduction
Inferior Oblique (IO)	Excyclotorsion	Elevation	Abduction

THE ACTIONS OF EACH EXTRAOCULAR MUSCLE

Observation 4: there are two muscles responsible for *elevating* the eye/moving the eye *upward.*

Superior Rectus is responsible for *elevating the eye when the eye is abducted.*

Extraocular Muscle	Primary Action	Secondary Action	Tertiary Action
Medial Rectus (MR)	Adduction	-	-
Lateral Rectus (LR)	Abduction	-	-
Superior Rectus (SR)	Elevation *of abducted eye*	Incyclotorsion	Adduction
Inferior Rectus (IR)	Depression	Excyclotorsion	Adduction
Superior Oblique (SO)	Incyclotorsion	Depression	Abduction
Inferior Oblique (IO)	Excyclotorsion	Elevation	Abduction

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THE ACTIONS OF EACH EXTRAOCULAR MUSCLE

Observation 4: there are two muscles responsible for *elevating* the eye/moving the eye *upward.*

Superior Rectus is responsible for *elevating the eye when the eye is abducted.*

Inferior Oblique is responsible for *elevating the eye when the eye is adducted.*

Extraocular Muscle	Primary Action	Secondary Action	Tertiary Action
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Superior Rectus (SR)	Elevation *of abducted eye*	Incyclotorsion	Adduction
Inferior Rectus (IR)	Depression	Excyclotorsion	Adduction
Superior Oblique (SO)	Incyclotorsion	Depression	Abduction
Inferior Oblique (IO)	Excyclotorsion	Elevation *of adducted eye*	Abduction

THE ACTIONS OF EACH EXTRAOCULAR MUSCLE

Observation 5: there are two muscles responsible for *depressing* the eye/moving the eye *downward*.

Extraocular Muscle	Primary Action	Secondary Action	Tertiary Action
Medial Rectus (MR)	Adduction	-	-
Lateral Rectus (LR)	Abduction	-	-
Superior Rectus (SR)	Elevation *of abducted eye*	Incyclotorsion	Adduction
Inferior Rectus (IR)	Depression	Excyclotorsion	Adduction
Superior Oblique (SO)	Incyclotorsion	Depression	Abduction
Inferior Oblique (IO)	Excyclotorsion	Elevation *of adducted eye*	Abduction

THE ACTIONS OF EACH EXTRAOCULAR MUSCLE

Observation 5: there are two muscles responsible for *depressing* the eye/moving the eye *downward*.

Inferior Rectus is responsible for *depressing the eye when the eye is abducted*.

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Inferior Rectus (IR)	Depression *of abducted eye*	Excyclotorsion	Adduction
Superior Oblique (SO)	Incyclotorsion	Depression	Abduction
Inferior Oblique (IO)	Excyclotorsion	Elevation *of adducted eye*	Abduction

THE ACTIONS OF EACH EXTRAOCULAR MUSCLE

Observation 5: there are two muscles responsible for *depressing* the eye/moving the eye *downward*.

Inferior Rectus is responsible for *depressing the eye when the eye is abducted*.

Superior Oblique is responsible for *depressing the eye when the eye is adducted*.

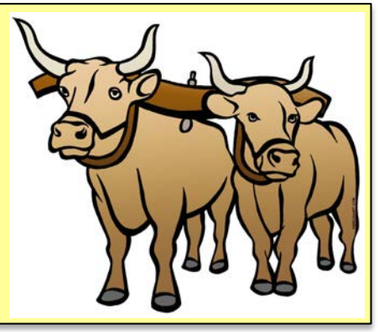
Extraocular Muscle	Primary Action	Secondary Action	Tertiary Action
Medial Rectus (MR)	Adduction	-	-
Lateral Rectus (LR)	Abduction	-	-
Superior Rectus (SR)	Elevation *of abducted eye*	Incyclotorsion	Adduction
Inferior Rectus (IR)	Depression *of abducted eye*	Excyclotorsion	Adduction
Superior Oblique (SO)	Incyclotorsion	Depression *of adducted eye*	Abduction
Inferior Oblique (IO)	Excyclotorsion	Elevation *of adducted eye*	Abduction

COORDINATING EYE MOVEMENTS

- The EOMs of the two eyes must work in a coordinated fashion in order to move the two eyes in the same direction.

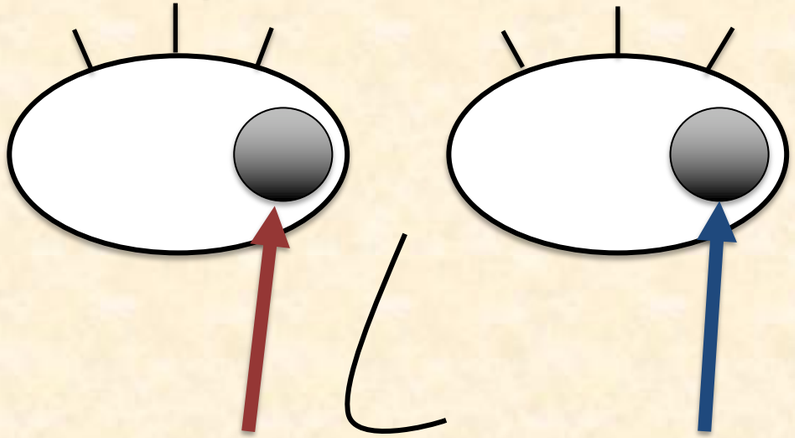
- The pair of muscles (one in each eye) used to move the eyes into a particular direction are referred to as *"yoked muscles."*

like the wooden beam used between a pair of oxen to enable them to pull a load together



Example of yoked muscles:

In order for this person to look to the left:
The medial rectus on the right eye needs to be activated, along with the lateral rectus of the left eye.



Right Eye (OD):
Medial rectus moves the right eye nasally (adduction)

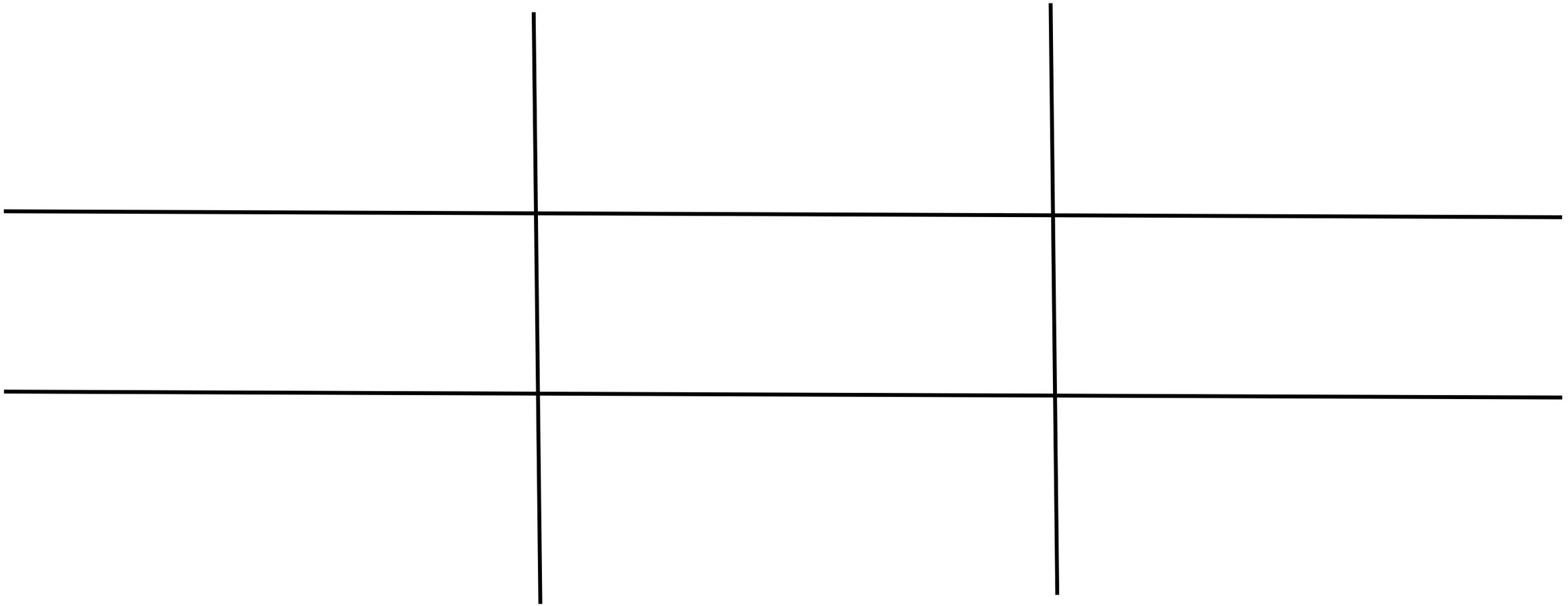
Left Eye (OS):
Lateral rectus moves the left eye temporally (abduction)

These muscles are thus *"yoked"* together.

[Source: https://pixy.org/1351360/]

MORAN EYE CENTER

THERE ARE 9 DIRECTIONS OF GAZE OR GAZE POSITIONS

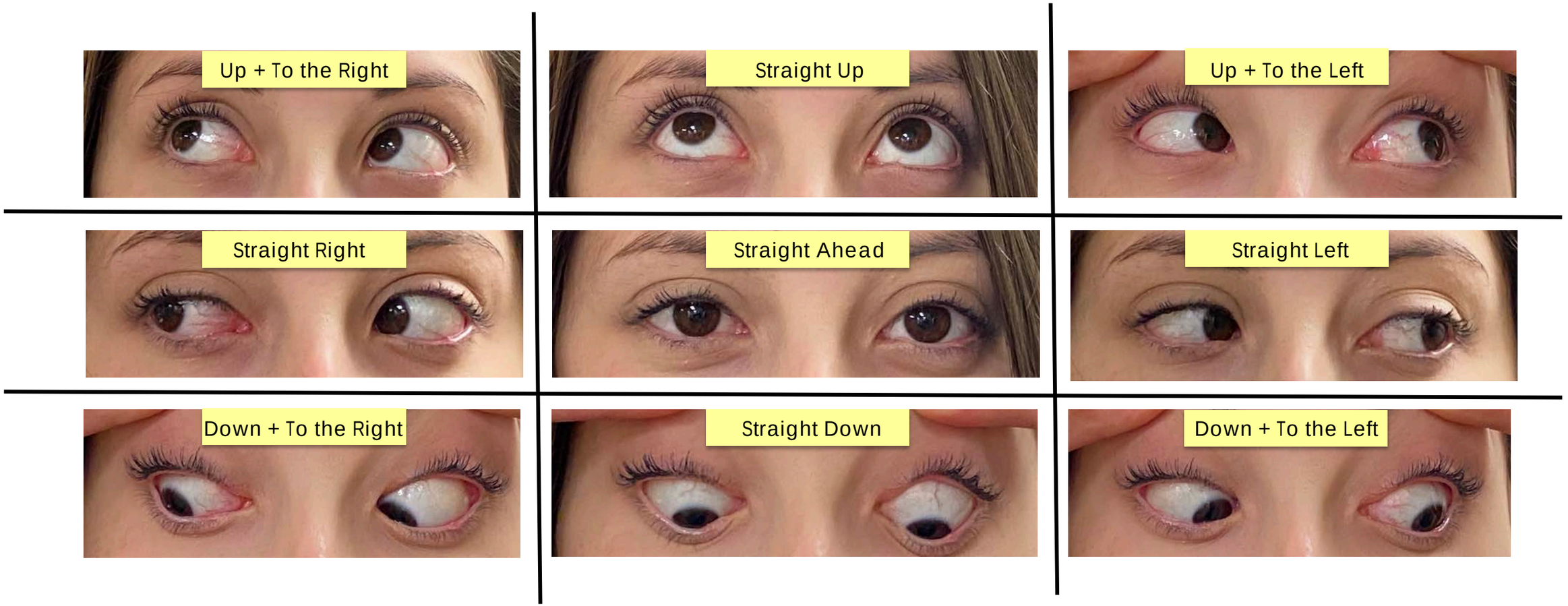


MORAN EYE CENTER

THERE ARE 9 DIRECTIONS OF GAZE OR GAZE POSITIONS

Up + To the Right	Straight Up	Up + To the Left
Straight Right	Straight Ahead	Straight Left
Down + To the Right	Straight Down	Down + To the Left

THERE ARE 9 DIRECTIONS OF GAZE OR GAZE POSITIONS



[Source: Sophia Fang, MD]

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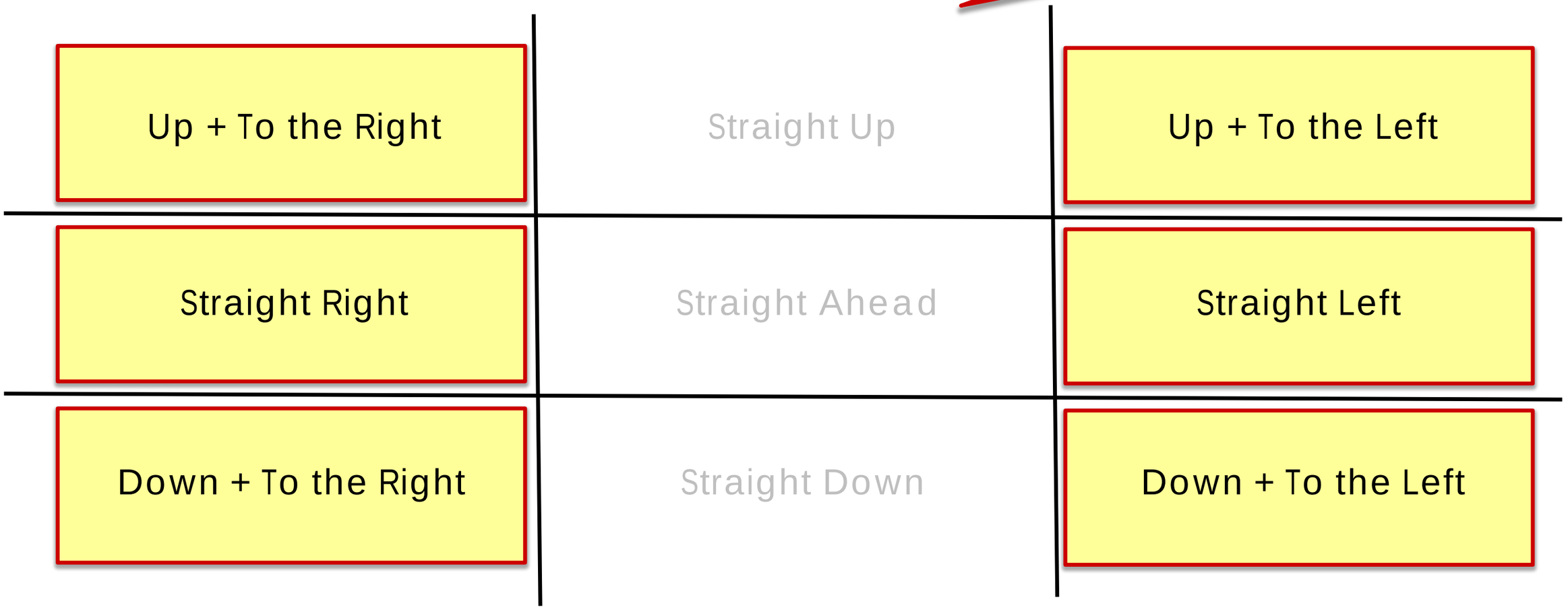
6 CARDINAL POSITIONS

*6 of the 9 gaze directions are called "**Cardinal** Positions"*



6 CARDINAL POSITIONS

Cardinal positions are special because in these positions, there is ONE muscle of EACH eye primarily responsible for moving that eye INTO that position (forming pairs of *yoked muscles*!)

Up + To the Right	Straight Up	Up + To the Left
Straight Right	Straight Ahead	Straight Left
Down + To the Right	Straight Down	Down + To the Left

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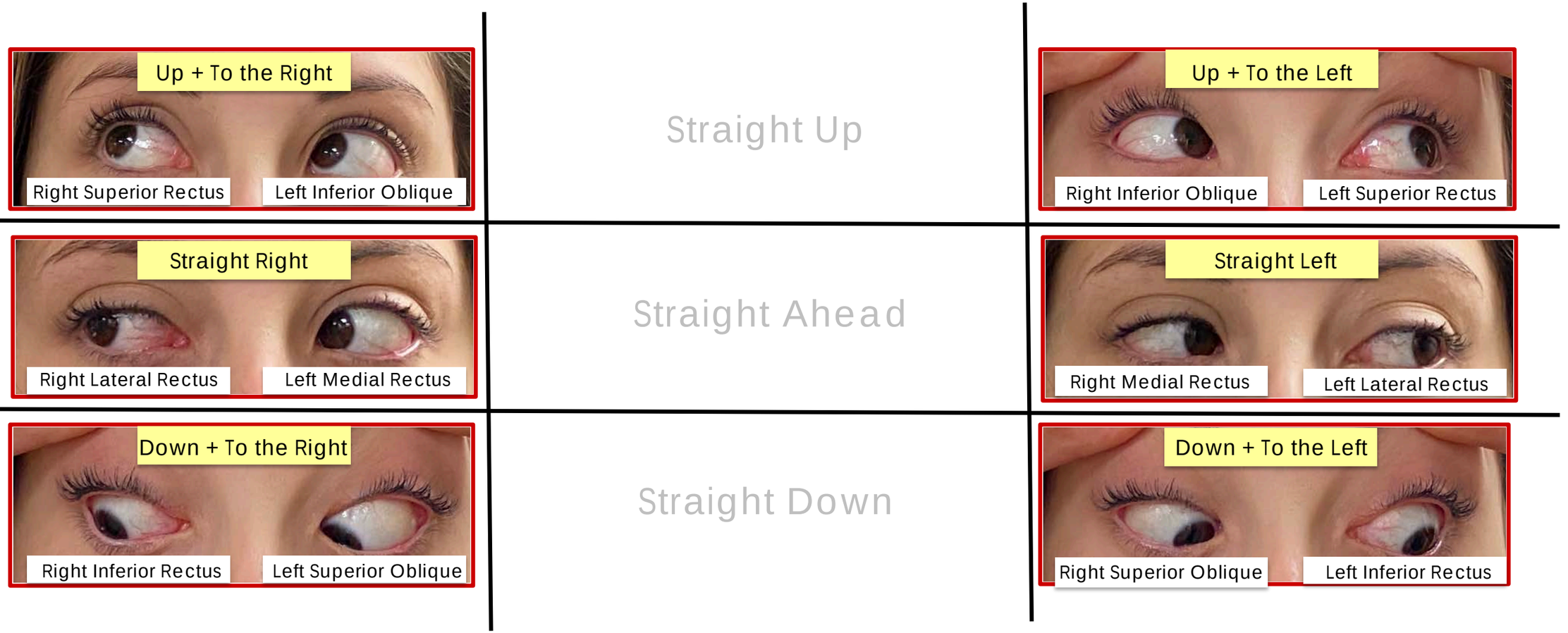
6 CARDINAL POSITIONS

with their corresponding yoked muscles



[Source: Sophia Fang, MD]

TESTING EXTRAOCULAR MOTILITY

How to Perform the “H” Test:

Tests the 6 cardinal positions

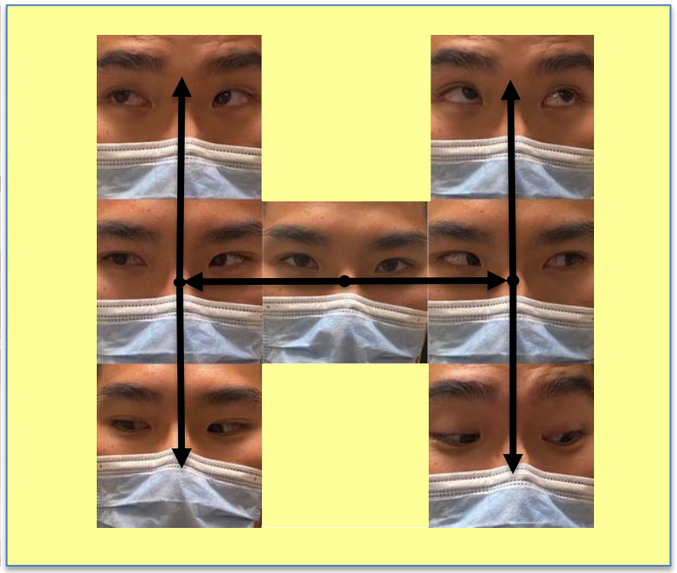
1. Ask the patient to sit upright.
2. Position yourself at eye level with the patient.
3. Use a small object such as the tip of your finger or the tip of a penlight held about 1 foot in front of the patient.
4. Ask the patient, with both eyes open and their head held still, to look at the object and follow it as you trace an “H” pattern in front of them.
5. The “H” that you trace should help you evaluate the full extent to which the patient can move their eyes into each of the cardinal positions.

Remember, ALL 9 gaze positions should be tested:
In addition to the H test, you should also test straight up and down gaze positions.

[Source: Video Courtesy of KieuYen Luu, MS4 and Vincent Tang, MS4]

WHAT TO LOOK FOR WHEN EVALUATING EXTRAOCULAR MOTILITY

1. Whether both eyes can move together in all gaze directions (see next slide).
2. Whether the patient is able to move their eyes to the full extent/excursion possible (that they are able to "bury the white" of the sclera)
3. Whether the movements are smooth.
4. Whether there is any nystagmus (involuntary rhythmic "shaking" of the eyes)



Remember to also test straight up and down movements!

[Source: Video Courtesy of KieuYen Luu, MS4 and Vincent Tang, MS4]

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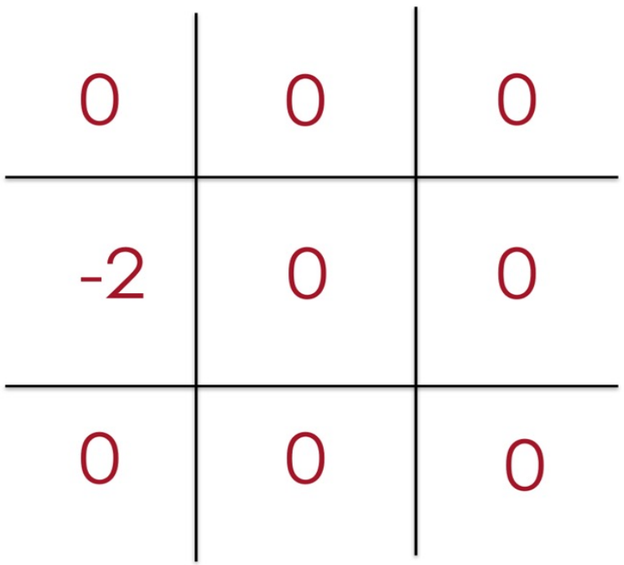
HOW TO DOCUMENT EXTRAOCULAR MOTILITY

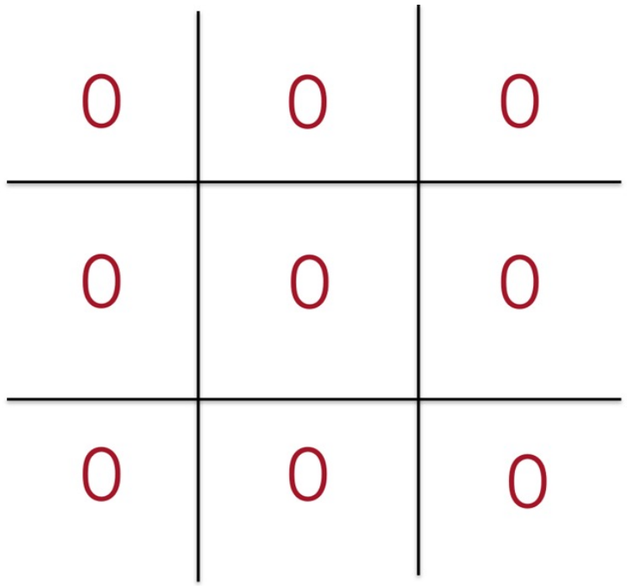
- Extraocular movement can be classified as either *Normal* or *Abnormal*
- If motility is *abnormal,* extraocular movement can be more than normal *(“overaction”)* or less than normal *(“underaction” or “deficit”)*
- One way of grading this is on a 9-point scale, ranging from *-4* to *+4*
  - 0 = normal, full movement
  - *-1* = 25% deficit of movement
  - *-2* = 50% deficit of movement
  - *-3* = 75% deficit of movement
  - *-4* = no movement of the eye past midline
- Positive values represent same equivalent percentages of excess movement

EXAMPLE OF HOW TO DOCUMENT

- You can document extraocular motility using a diagram representing the 9 gaze positions and primary gaze



Right eye (OD)



Left eye (OS)

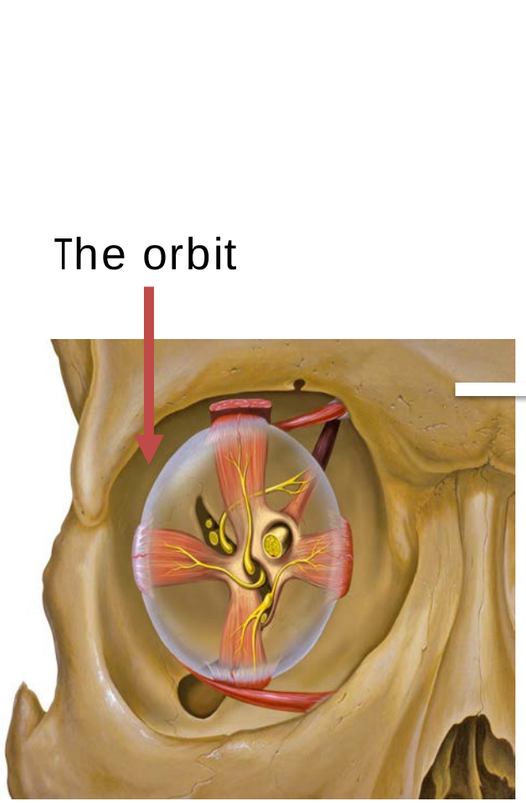
- The “-2” in the right eye at the position above indicates a 50% reduction in the expected normal extent of abduction

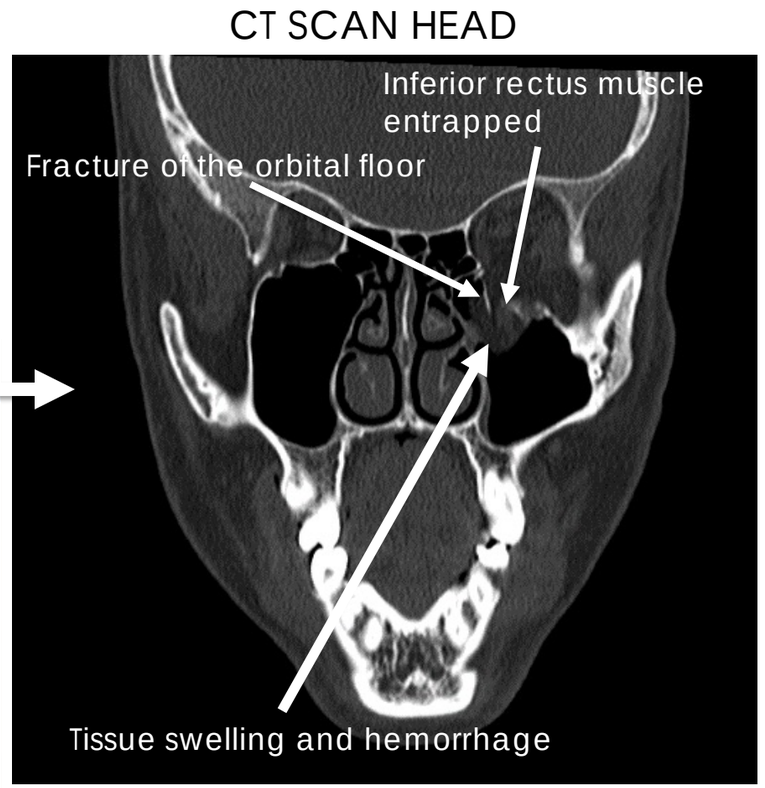
WHY IS ASSESSING EXTRAOCULAR MOTILITY IMPORTANT?

- Abnormal motility can be a sign of a neurologic condition such as a stroke, trauma, or multiple sclerosis.
- A patient with abnormalities in extraocular motility may or may not be symptomatic.
  - Symptoms, when present, can include:
    - Diplopia (double vision)
    - Deficits in depth perception
    - Nausea/Vomiting
    - Eye pain
    - Headache
    - Asthenopia (eye strain)
    - Blurry vision

ABNORMAL MOTILITY: EOM ENTRAPMENT

- The eye and its EOMs are surrounded by a bony orbit.
- Fractures of these orbital bones from trauma can lead to swelling, hemorrhage, and EOM entrapment which can restrict movement and cut off their blood supply!
  - These cases require immediate surgery!
- Symptoms can include pain, diplopia, nausea, and slowed heart rate (bradycardia) due to nerve involvement





[Source: https://commons.wikimedia.org/wiki/File:Eye_orbit_anterior.jpg]
[Source: CT scan courtesy of UC Davis Health]

ABNORMAL MOTILITY: CRANIAL NERVE 6 PALSY

1. When the patient is asked to look to her left, the right eye appears to move normally.

2. When the patient looks straight, the right eye is turned in (esotropia)

3. When the patient is asked to look to her right, notice how the right eye is unable to abduct past midline

Left gaze: no deviation | Primary position: right esotropia | Right gaze: left esotropia

- Esotropia is a form of ocular misalignment where there is an inward turn of one or both eyes.
- Cranial nerve 6 palsy is most commonly caused from ischemic diseases such as diabetes and hypertension
- Recall that cranial nerve 6 innervates the lateral rectus (LR), which is responsible for abduction (lateral movement) of the eye.
- Patients with cranial nerve 6 palsy can present with diplopia and esotropia.

[Source: https://morancore.utah.edu/cranial-nerve-vi-palsies/]

SUMMARY

- Assessing extraocular motility is an important part of the eye examination.
- This can be done with the “H” test in addition to testing straight up and down.
- Motility abnormalities can lead to symptoms such as diplopia, problems with depth perception, nausea, vomiting, eye pain, headache, asthenopia, photophobia, and blurry vision.
- Motility abnormalities can be a sign of EOM entrapment, vascular disease, or neurological disease, which requires careful ophthalmic evaluation, and possibly urgent systemic workup.

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