Practical anatomy and physiology of the ocular motor system

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Objectives

- To understand the relationship between the oculomotor and the vestibular system.
- Knowledge of the orbital anatomy.
- Knowledge of the types of eye movements.
- In depth knowledge of vestibular eye movements.
- Knowledge of nystagmus.

Role of oculomotor system in balance

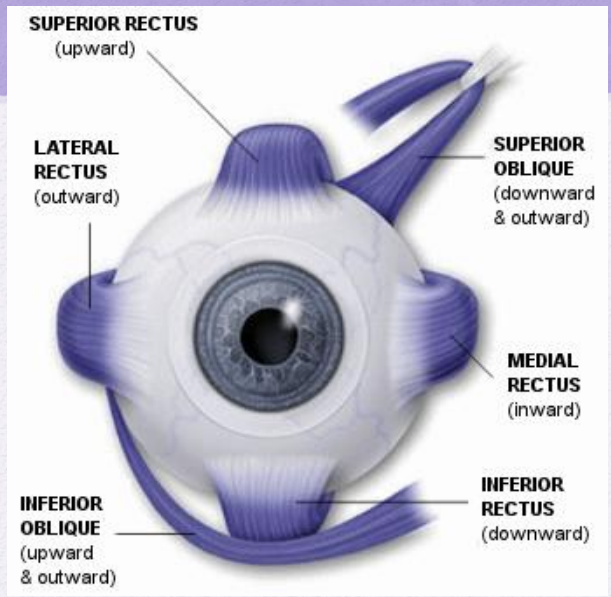
- Balance involves complex integration of vision, proprioception, and the vestibular system.
- It therefore difficult to identify specific causes for balance disorders.
- Vestibular system is closely linked to vision and most vestibular deficits produce or modify eye movements.
- Understanding the origin of eye movements and how they are influenced by the vestibular system is therefore very important for the diagnosis of balance disorders.

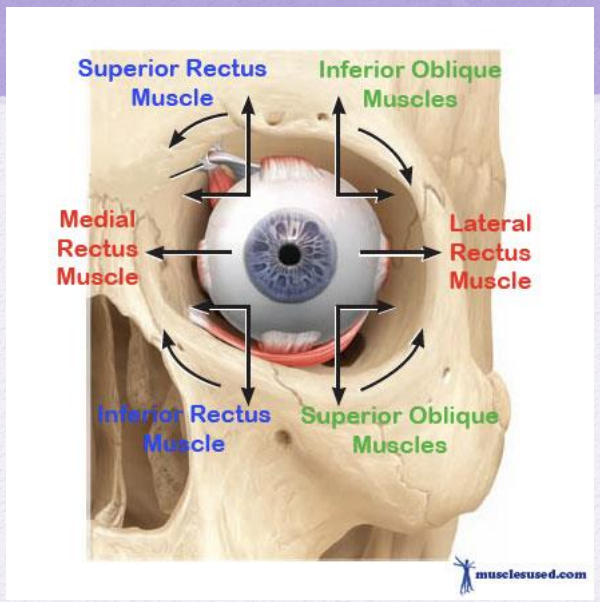
Why to assess oculomotor function?

- Problems with oculomotor function can affect the integrity of the contribution of vision to balance.
- Vestibulo-ocular reflexes are used to assess vestibular function.
- The maintenance of gaze is one of the primary functions of the vestibular system (Herdman,).

ORBITAL ANATOMY

- The orbit sits in place as a result of the tone of six muscles attached to it.
- During movement, the contraction of each muscle must be accompanied by a stretching in the antagonist muscle.




Superior Rectus Muscle
Inferior Oblique Muscles
Medial Rectus Muscle
Lateral Rectus Muscle
Inferior Rectus Muscle
Superior Oblique Muscles
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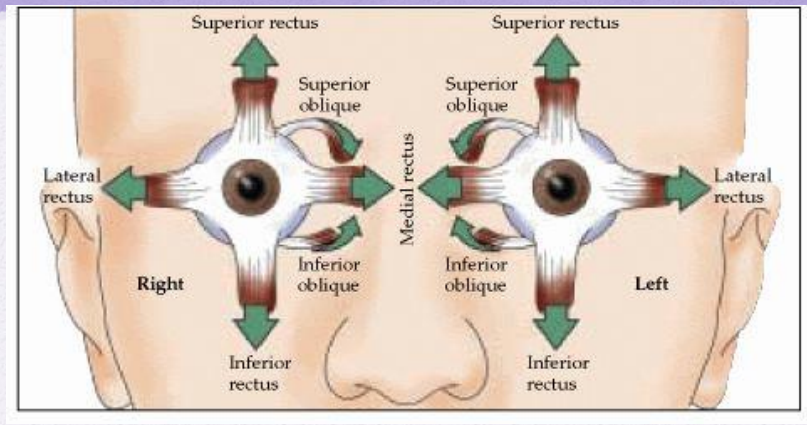

Superior rectus
Superior rectus
Superior oblique
Superior oblique
Lateral rectus
Medial rectus
Lateral rectus
Right
Left
Inferior oblique
Inferior oblique
Inferior rectus
Inferior rectus

Extraocular Muscles

- 3 pairs (6 muscles).
- 4 recti muscles (medial, lateral, superior, inferior).
- 2 oblique muscles (superior, inferior).

Video 1

https://www.youtube.com/watch?v=vd7OOJ7c1q4

Eye muscle	Primary action	Secondary action	Tertiary action
Medial rectus	Inwards – towards nose		
Lateral rectus	Outward – away from nose		
Superior rectus	Upward	Rotates top of eye towards nose	Inward
Inferior rectus	Downward	Rotates top of eye away from nose	Inward
Superior oblique	Rotates top of eye toward nose	Downward	Outward
Inferior oblique	Rotates top of eye away from nose	Upward	Outward

Eye muscle	Primary action
Medial rectus	Adduction
Lateral rectus	Abduction
Superior rectus	Elevation
Inferior rectus	Depression
Superior oblique	Intorsion
Inferior oblique	Extorsion

Axes of ocular rotations

- The axes of rotations are not perpendicular to the visual axis.
- E.g. an upward movement of the pupil is caused by different muscles when the eye is pointed medially compared to a lateral starting position, so there is no direct relationship between a vertical movement described in this fashion and the muscles that need to be stimulated.

Purpose of eye movement

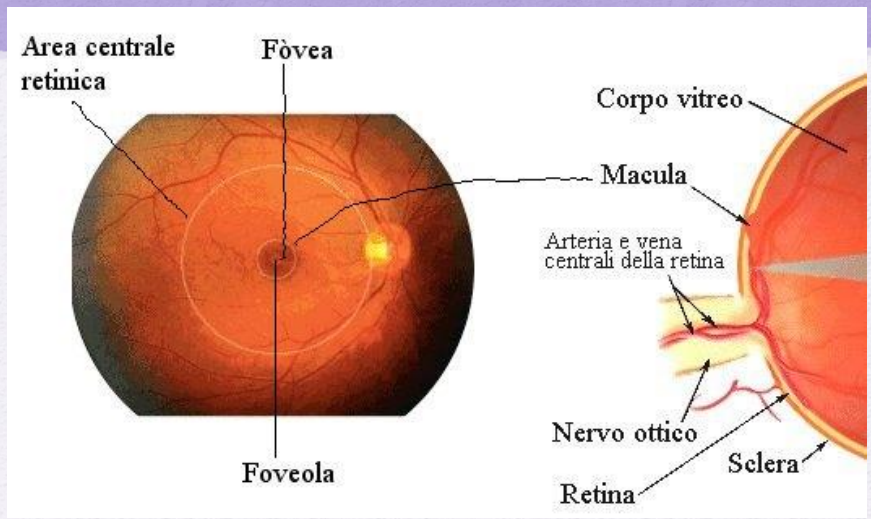
- Stabilize image of the fovea (during head or target movement).
- Move to a new target.

TYPES OF EYE MOVEMENT

- Versions: Conjugate eye movement (both pupils moving in the same direction).
- Vergence: Pupils moving in opposite direction.

Conjugate eye movement and foveal vision

- Fovea: 5 degrees region of the retina. Light transducing cells are tightly packed here.
- Foveola: 0.8 degrees spot providing best resolution of visual images.
- Eyes are frontally directed, therefore:
- Must point directly at the target.
- L/R eyes must move together.



Versions and Gaze

- Versions
- conjugate eye movement. Needed for image stabilization.
- Move the eyes at the same time in the same direction.
- Gaze: line sight with respect to objects in the environment.

Versions and Gaze

Figure 2A: Look straight ahead.

Figure 2B: Turn your head 45 degrees towards the right.

Figure 2C: Turn your head 45 degrees towards the left.

Note: Business card should be positioned at eye level. (c) T.C.Hain, 2002

Video 2

https://www.youtube.com/watch?v=6GliSCGkpZ4

Disjunctive Movements Serving Binocular Vision

- To enhance the depth of perception both foveae must be pointed directly at the objects in regard.
- The image from each eye should be similar.
- Mismatch of images from both eyes results in diplopia (double vision).

Video diplopia

- https://www.youtube.com/watch?v=iP2VCZzR1Ic

CONJUGATE EYE MOVEMENTS

- Saccades.
- Smooth pursuit.
- Optokinetic.
- Fixation.
- Vestibular eye movements.

Saccades

- Rapid eye movement.
- Very quick.
- Horizontal or vertical
- Accuracy.
- Latency is up to 200 ms.
- Corrective saccade.
- Highest demands on the ocular muscles.
- Indications of abnormal saccades (muscular lesion, central lesion).

Video 4 and 5

https://www.youtube.com/watch?v=P6uTlnyNaTs

https://www.youtube.com/watch?v=2NtaDHtY4KE

Smooth pursuit

- Tracking movements.
- Tracing moving objects.
- Match eye velocity with the velocity of the moving object.
- Still eye/moving target.
- Not accurate for targets moving > 10 degrees/sec.
- Catch up saccades.
- Improve with practice.
- Age related norms are important.
- Abnormal pursuit indicates central lesion.

Video 6 & 7

- https://www.youtube.com/watch?v=XIfIWk0VscY
- https://www.youtube.com/watch?v=Aoi15ExYW3M

Optokinetic system

- Produces eye movements to provide visual stabilization during sustained head movements
- Repetitive eye movement in response to the movement of full visual field images, either rotation of an image before the subject, such as a drum with vertical black stripes on a white background, or rocking of a mirror back and forth in front of the patient's eyes.
- Alternating fast saccade in one direction and a smooth pursuit in the other direction.
- Generated eye movements are alternating slow pursuit at near target velocity and fast centering saccades.

Video 8 and 9

https://www.youtube.com/watch?v=KSJksSA6Q-A

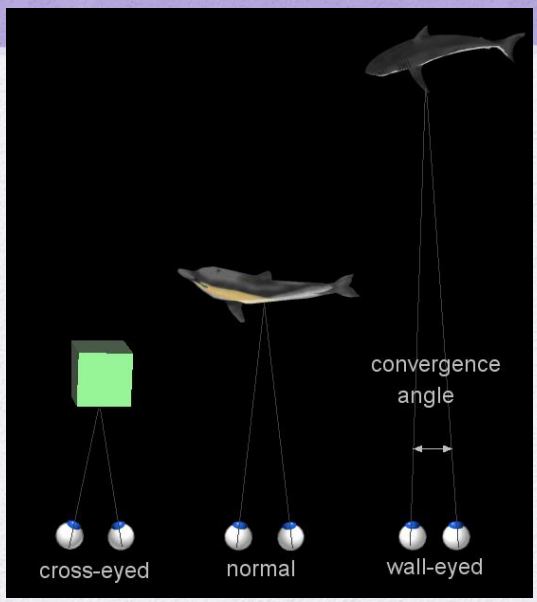
https://www.youtube.com/watch?v=J5XGOSb4FHU

Fixation

- The ability to maintain gaze on a target.
- Require continuous tiny corrective saccades and drifts to maintain correct eye position.
- Corrective movements in subjects with normal fixation are very small. Therefore, cannot be seen or measured.
- Might be measurable is subjects with abnormal fixation.

Vergence

- Eyes move in an opposite but coordinated fashion.
- Disjunctive eye movement to a new target at a new distance.
- Tow types; convergence and divergence.
- Convergence: both eyes move together to fixate on a close object.
- Divergence: eyes move apart to view more distant object.
- Slow smooth movements in response to image fusion or blurring
- Usually accompanied by saccade



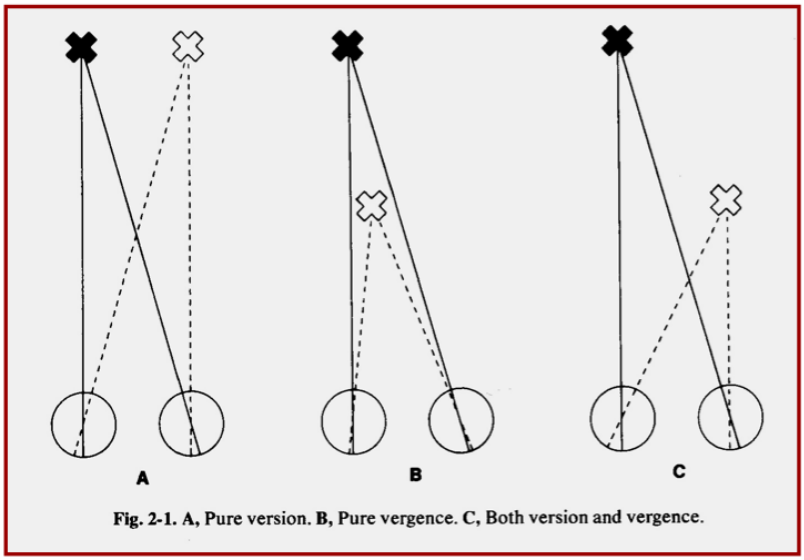


Fig. 2-1. A, Pure version. B, Pure vergence. C, Both version and vergence.

Video 10

https://www.youtube.com/watch?v=7g1w6IjZ5SU