Eye Movements

*MHD – Neuroscience Module*

January 28, 2016

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**Objectives**

- Describe the actions of the extraocular muscles
- Outline conjugate eye movements, pathways and components
  - Slow/pursuit eye movements (PPRF, MLF, vestibuloocular reflex)
  - Fast/ballistic/saccadic eye movements (frontal eye fields)
- Describe components/pathway for vergence eye movements
- Define/describe internuclear ophthalmoplegia
**Ocular Motility**

- Motility is controlled by six extraocular muscles
  - Four rectus muscles (superior, inferior, lateral, medial)
  - Originate from a common tendinous ring (annulus of Zinn)
  - Insert anteriorly in the sclera
- Two oblique muscles (superior and inferior)
  - Originate from the sphenoid bone (back of the orbit, SO) or the front medial floor of the orbit (IO)
  - Insert posteriorly in the sclera
- Fast and precisely controlled, motor units are unusually small, composed of fatigue-resistant type 2A fibers
- Binocular vision necessitates precise alignment of both eyes

- Coordinated changes involve activity of all six extraocular muscles
  - Each muscle has a primary and secondary action when starting from a primary position
  - Action is determined by direction and position of tendon insertion
  - Vertical recti & oblique muscles have functions that vary according to eye position

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**“Cardinal” positions of gaze – a theoretical concept**

[Diagram showing cardinal gaze positions]

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**Eye structures passing through the orbital fissures**

[Diagram showing eye structures and their passes through the orbital fissures]

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*Modified from Schuenke M, Schulte E, Schumacher U. Thieme Head and Neuroanatomy, 2007*
Conjugate eye movements – slow/pursuit

Slow eye movements that keep images on the fovea (ω=100 degrees/s), allow continuous feedback from vestibular and visual systems to regulate speed/duration

- Smooth/pursuit movements
  - V固al feedback keeps images of moving targets on the fovea
  - Volitional, originates in the extrastriate cortex & uniquely requires cerebellum (flocculus) for its generation

- Vestibuloocular reflex (clinically tested as part of the Dand’s eyes maneuver)
  - Generates compensatory eye movements in opposite direction from head movements, relies on vestibular input
  - Can be suppressed to allow head and eye movements to shift gaze

- Vergence movements
  - Accommodation signals are used to guide vergence eye movements (CN III, MR)
  - Cerebellum involved but not essential for movements

- Optokinetic movements
  - Compensates for head movement, but relies on visual cues to the entire retina

Centers for Conjugate Gaze

- Brainstem
  - Rostral interstitial nucleus (vertical gaze center)
  - PPRF (horizontal gaze center)

- Cortical
  - “Frontal eye field”
    - Brings an object onto the fovea
    - Initiates saccadic eye mov. ’s
  - “Occipital eye field”
    - Keeps an object on the fovea
    - Necessary for smooth pursuit

Schuenke M, Schulte E, Schumacher U. Thieme Head and Neuroanatomy, 2007

http://www.instantanatomy.net

Cavernous sinus (not this detail on the exam)
Pursuit eye movement recording

This is a volitional eye movement that is attempting to "guess" where the target is going and to move the fovea onto it as quickly as possible. During a saccadic eye movement, vision is blurred. Once the target is reached, smooth pursuit takes over and, as long as the target is moving slowly, can keep the fovea on it and allow a sharp image; smooth pursuit is a reflex and "automatic." In this recording the eyes don't have a target so, smooth pursuit can't occur and all you see are fast saccadic eye movements as the brain tries to follow a virtual target smoothly, but can't.

Vestibuloocular reflex (VOR)

• Stabilizes the image on the retina during a rotation of the head and faster than visual tracking
• As the head rotates the VOR rotates the eyes with the same speed, but in the opposite direction
• Without this reflex, the image would appear "smeared" upon the retina
• Once the head stops moving the eyes remain in that same direction of gaze
  – “Stabilization" occurs through the nucleus prepositus hypoglossi
  – Tonic activation maintains the activation/activity of the involved cranial nerve nuclei (the 3rd and 6th)

Eye movement integration with vestibular system
Vestibular pathways involved with eye movements

- Head is rotating to the right
  - The right horizontal canal is activated
  - The right vestibular nucleus is activated
  - The left 6th nucleus (via PPRF) is activated and the left lateral rectus muscle contracts
  - The left PPRF "activates" neurons in the right 3rd nucleus and the right medial rectus contracts
  - … both eyes begin to move to the left
  - The object of interest "stays" on the fovea

Vestibuloocular reflex

- Fast eye movements that move an image onto the fovea (~700 degrees/s); brainstem motor programs that are triggered by cerebral or cerebellar centers:
  - Ballistic eye movements place an image onto the fovea, same as fast phase of nystagmus
  - Initiated from the contralateral frontal eye fields (middle frontal gyrus)
  - Used in reading, scanning scenes & pictures, etc.
  - Modulated by output from basal ganglia, inhibits frontal & supplementary eye fields, etc.
  - Modulated by the cerebellum (vermis), regulates timing of muscle contractions (dysmetric saccades)
  - Rapid horizontal eye movements - generated from the paramedian pontine reticular formation (PPRF)
  - Rapid vertical eye movements - generated from the reticular formation dorsomedial to the red nucleus (cMl.F)
Conjugate eye movements — saccadic (volitional looking to the left)

Ophthalmoplegia

Pathway for the near reflex