Understanding Eye Movements

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Primary Motor Pathway

UMN

Cerebral Cortex

Spinal Cord

LMN

Muscle
The control of eye movements is mediated through multiple neural circuits interconnect cortex, basal ganglia, vestibular nuclei, cerebellum & ocular motor nuclei in the brain stem.

The ocular motor system consists of supranuclear, internuclear & nuclear components.
1. **Supranuclear:** descending fibers from cerebral hemispheres to brain stem (frontal eye fields)

2. **Internuclear:** interconnections between nuclei (MLF)

3. **Nuclear:** nuclei of 3rd, 4th and 6th cranial nerves

- The ocular motor system has one purpose to **place & maintain** the images of regard on the fovea.
- The task becomes more complex when the objects, the head or both are moving.
Functional Classification of Eye Movement Systems

Direct the fovea to an object of interest:
- Saccades
- Smooth pursuit
- Vergence

Hold images steady on the retina:
- Fixation
- Vestibulo-ocular reflex (VOR)
- Optokinetic nystagmus

From: Anges M.F. Wong, Eye Movement Disorders, Oxford University Press, 2008
Saccades

- Bring images rapidly onto the fovea.
- Velocity: 300 – 700° / sec.
- Intentional, reflexive & spontaneous types.
- The frontal eye field controls saccades to the contralateral direction.

Pursuit

- Holds the image of a moving target on the fovea.
- Velocity: up to 100° / sec.
- Parieto-occipito-temporal region controls pursuit in the epsilateral direction.
Vergence Eye Movements

- Maintain fusion of images when targets move towards or away from the eyes.
- Velocity: 20° / sec.
- Control center lies in the midbrain.

Vestibulo-ocular Reflex (VOR)

- Maintains fixation during brief head movements.
- Input from vestibular nuclei travels through MLF to ocular motor nuclei.
- Checked by oculo-cephalic maneuver, caloric testing or rotating chair.
Optokinetic Nystagmus (OKN)

- Maintains fixation during target movement or sustained head movements.
- Fast & slow phases.
- Fast phase is controlled by contralateral frontal eye field & slow phase by ipsilateral parieto-occipito-temporal area.

Role of Cerebellum

- Controls smoothness of pursuit movements & accuracy of saccades.
- Maintenance of eccentric gaze.
Neural Integrator

- Eye movement is affected by the properties of the eyeball, suspensory ligaments and orbital fascia
- Eccentric gaze holding is the function of neural integrator
- Inputs from the nucleus prepositus hypoglossi and the medial vestibular nuclei to the abducens nucleus

Horizontal Gaze Neuro-anatomy (Saccades)
Horizontal Gaze Neuro-anatomy (Pursuit)

Vertical Gaze Neuro-anatomy
Approach

Clinical picture:
- Double vision (3rd, 4th, 6th N palsy or vergence disorders)
- Blurring of vision, dizziness (conjugate movement disorders)
- Neurological deficit

Examination:
- Inspection
- Pursuit movements
- Cover test
- Saccadic movements
- Optokinetic nystagmus
- Vestibulo-ocular reflex
- Fundus
- Directed neurological examination
Examination

Inspection:

Examination

Pursuit Movements:
Cover Test:

Saccadic Movements:
Examination

Optokinetic Nystagmus:

Examination

Vestibulo-ocular Reflex:
Localization:
- Horizontal gaze palsy: \(\rightarrow\) (cerebral cortex or pontine lesions)
- Vertical gaze palsy: \(\rightarrow\) (midbrain lesions)
- Gaze palsy with intact VOR: \(\rightarrow\) (supranuclear lesions)
- 3rd, 4th, 6th nerve palsy \(\rightarrow\) (nuclear or infranuclear lesion)

Differential Diagnosis
1. Myasthenia gravis
2. Myopathies
3. Orbital disease
Case: 1

MRI
Conclusion

- The main function of the ocular motor system is to place & maintain the images of regard on the fovea.

- The control of eye movements is mediated through multiple neural circuits interconnect cortex, basal ganglia, vestibular nuclei, cerebellum & ocular motor nuclei in the brain stem.

- Although supranuclear palsy could be asymptomatic, yet ocular motor nerves palsy present with double vision & ocular misalignment.

Conclusion

- Gaze abnormalities never exist in neurological isolation.

- Neuro-imaging & neurological evaluation are mandatory.
Thank you