5.7.1. Supranuclear Disorders of Ocular Motility (I)

Efferent visual system

- "ocular motor system"
- controls ocular movements
- 2 pathways
  - **supranuclear pathways**
    - premotor and motor regions of the frontal and parietal cortices

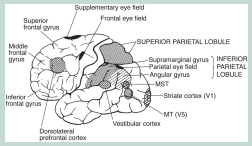

Figure 1-23 (© 2020 American Academy of Ophthalmology)

    - cerebellum
    - basal ganglia
    - superior colliculi
    - thalamus (dorsal lateral geniculate nucleus and pulvinar)
    - brainstem centers (paramedian pontine reticular formation, neural integrators, and vestibular nuclei)

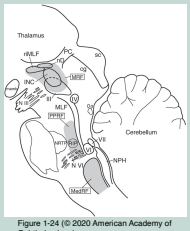

Figure 1-24 (© 2020 American Academy of Ophthalmology)

    - except skew deviation!
    - do not produce diplopia ✗
    - affect both eyes similarly ★
    - supranuclear disorders
  - **infranuclear pathways**
    - ocular motor nuclei
    - intramedullary segments of the ocular motor nerves
    - peripheral segments of the ocular motor nerves
      - coursing through the subarachnoid space, cavernous sinus, superior orbital fissure, and orbit
    - neuromuscular junction
    - extraocular muscles
    - produce diplopia ★
    - affect the eyes differently ★
    - infranuclear disorders

Eye movements

- vestibular ocular reflex (VOR) system
  - brief, high-frequency rotations of the head
- optokinetic nystagmus (OKN) system
  - sustained rotation of the head (or environment)
- pursuit system
  - tracking relatively slow-moving (<30° per second) targets

Supranuclear centers

- Saccadic system
  - frontal eye field (FEF)
    - contralateral paramedian pontine reticular formation (PPRF)
  - horizontal eye movements
    - pulse
      - FEF
        - contralateral paramedian pontine reticular formation (PPRF)
    - step
      - medial vestibular nucleus
      - accessory nucleus of CN XII
  - vertical and torsional eye movements
    - pulse
      - rostral interstitial nucleus of the medial longitudinal fasciculus (riMLF)
        - midbrain
    - step
      - interstitial nucleus of Cajal (INC)
- Vergence
  - mesencephalic reticular formation
- Pursuit system
  - anatomy
    - cerebral cortex
      - FEF
      - middle temporal (MT) area
      - medial superior temporal (MST) area
      - posterior parietal cortex
    - an area at the confluence of the parietal, temporal, and occipital lobes
      - descending pathways
        - pass through the posterior limb of the internal capsule
    - brainstem
      - uses some of the same architecture described for saccades
        - medial longitudinal fasciculus [MLF]
        - cranial nerve nuclei
      - several other pontine nuclei
        - project to the cerebellum
          - paraflocculus plays a role in sustaining pursuit movements

Fundamental Principles of Ocular Motor Control

- attention to peripherally placed objects is driven by the perception of a changing stimulus
  - movement is an especially strong stimulus!
    - See Table 7-1
- pursuit system
  - for tracking relatively slow-moving (<30° per second) targets
    - 1/3 the distance from the primary position to the far extent of the temporal visual field in 1 second
  - driven by visual attention to a target
    - foveation
      - moving target ✓
      - moving person ✓
- vestibular ocular reflex (VOR) system
  - holds images stable on the retina during brief, high-frequency rotations of the head
    - walking
  - produces eye movements in a direction opposite to those of head acceleration
  - attenuates quickly (within seconds) during prolonged period of stable head velocity
  - holds images stable on the retina during sustained rotation of the head (or environment)
- optokinetic nystagmus (OKN) system
  - supplements the VOR
    - during prolonged visual movement (running continuously), the OKN system maintains visual fixation even after vestibular influence has waned
  - the pursuit system is more influential in maintaining proper alignment during sustained rotations than the OKN system
  - 2 components
    - 1 initial smooth pursuit to track a moving object
    - 2 saccade in the opposite direction
      - the maximum amplitude of the pursuit movement is reached ✓
      - speed of the moving object exceeds the maximum velocity of the pursuit system ✓
      - involuntary saccade is mediated by the same vestibular neurons that respond to vestibular stimulation ✓
        - integrity of the vestibular neurons can be studied without using vestibular stimuli!
  - both OKN and VOR can be suppressed by visual fixation on a target ★
- saccadic system
  - rapidly shifts the fovea to targets of interest
    - for tracking faster-moving targets
    - relatively fast, back-to-back eye movements
      - duration is generally <100 milliseconds
  - "ballistic" movements
    - cannot be altered once initiated!
  - larger-amplitude saccades are faster than smaller-amplitude saccades
    - "main sequence"
    - may exceed 500° per second
      - from primary position to the farthest extent of the temporal visual field in only 0.2 second
- vergence systems
  - for tracking objects moving toward or away from the eyes
    - convergence
    - divergence
  - driven primarily by a disparity in the relative location of images on the retinas
- microsaccadic refixation movements
  - persistent foveal fixation on a stationary target causes attenuation of retinal neuronal responses
  - to-and-fro movements maintain the image within the field of the fovea
    - very small amplitude (0.1°–0.2°)
    - continuous
    - slight pause (180–200 ms) between movements (intersaccadic interval)
    - "square waves"
- abnormalities in any of these systems may result in
  - degradation of visual acuity
  - blurring of vision
  - oscillopsia
  - motion sickness
- pursuit, OKN, and saccadic systems are controlled by different anatomical pathways that converge at the level of the brainstem
  - share the same supranuclear neurons
    - paramedian pontine reticular formation (PPRF)
      - for horizontal movements
    - rostral interstitial nucleus of the medial longitudinal fasciculus
      - for vertical movements
    - innervate the ocular motor cranial nerve nuclei

Ophthalmology Mind Maps/Arman Mashayekhi, MD