GEOMETERY HANDOUT

ORBITAL GEOMETRY

Ball and virtual socket (muscle basket & orbit)-

Centrode and center of rotation

Orbit

Medial walls of orbits nearly parallel

Lateral walls make nearly 90 deg angle

MUSCLE MECHANICS

Three Muscle planes

Horizontal movers

All four horizontal rectus muscles are in the same plane.

Vertical movers

Vertical Recti - 23 degrees temporal in each eye

Obliques - 53 degrees nasal in each eye

Angles of muscle planes correspond to Semicircular canal planes across species

Muscles have Primary, Secondary and Tertiary actions

Muscle pairings

Actions- primary, secondary and tertiary

Simplify control by reducing “degrees of freedom”

Antagonist pairs- primary actions are opposed within an eye

LR <-> MR; SR <-> IR; SO <-> IO

Yoked pairs- primary actions keep two eyes aligned for H and V

L LR <-> R MR; L SR <-> R IO; L IR <-> R SO

Head tilt pairs- keep eyes aligned during head tilt

Mediated by otoliths

Lower eye intorts and elevates, higher eye extorts and depresses.

This pairs L SR <-> L SO; R IR <-> R IO

Benzene ring notation

Diagnostic gaze positions (evaluation of noncomitancy).

Parks 3 step test for vertical deviation- (assumes single muscle is paretic)

This is a test to find out which muscle is causing one eye to be elevated (hypertropia). We narrow it down with three questions:

1) Right or Left hypertropia?

2) Worse on Left gaze or Right gaze?

3) Worse with Head tilt left or right?

Ex. Left SO palsy (pretty common): left eye is hyper, it’s worse on right gaze and it’s worse on left head tilt.

Muscle fields in primary position of gaze

Hess Screen

Landcaster projection test

OCULOMOTOR BEHAVIOR

Eye position "Laws"

These are generalizations about how eye positions are determined by the nervous system. They are all violated on a regular basis.

DeCartes- Sherrington's Law

Reciprocal innervation of antagonist muscle pairs: As agonist innervation increases, antagonist innervation decreases.

Hering's Law

Equal innervation of yoked muscle pairs.

"...one and the same impulse of will directs both eyes simultaneously as one can direct a pair of horses with single reins."

Ex: For dextroversion, R LR and L MR innervation increases together; for convergence, R MR and L MR innervation increases together.

Donders' Law

Each gaze direction has a unique torsional posture, no matter what path the eye took to get there.

Listing's Law

Rotation axis is always (approximately) in frontal plane for all eye positions. Eye behaves AS IF it were held by springs, so that torsion is predicted by a polar coordiate system. Listing's Law is only valid for steady gaze positions, it is violated during many eye movements.

Final common pathway handout

Muscle Efferents - Cranial Nerves III, IV, VI

Extraocular and Intraocular muscles are controlled by three Cranial Nerves: III, IV, VI

Each Nerve arises from a grouping of neurons in the brainstem called the **Nucleus**, has a portion where the fibers course through the surrounding region of the brainstem called the **Fascicle**, and then a portion where the fibers leave the brainstem, enter the subarachnoid space and collect to form the **Nerve**.

Damage to any of these can produce a **paresis** (weakness) or **palsy** (total paralysis) of one or more muscles. Paralysis of several muscles is called **Ophthalmoplegia**. The term **Oculomotor Ophthalmoplegia** refers to loss of IIIrd nerve control, but is sometimes used to mean total loss of muscular control of an eye.

Oculomotor Nuclei represent the **Final Common Path** for all the eye movement control systems. At this level, the same motoneurons are active for all types of eye movement- saccades, VOR, OKN, pursuit, etc.

Oculomotor Nerve (III)

Levator, SR, MR, IR, IO, parasympathetic fibers to Ciliary body for pupil constriction and positive accommodation.

Nerve III palsies almost always involve both extraocular and intraocular muscles, but rarely one may see the first signs of palsy as a unilateral dilated, unresponsive pupil.

Most common Nerve III palsy is caused by aneurism of posterior communicating artery because it runs parallel to pca for about 5 mm. (down and out syndrome)

Fascicle of Nerve III

Fibers from each side pass through brainstem for some distance, near Red Nucleus and Substantia Nigra

Lesion affecting fascicle will often cause ipsilateral ophthalmoplegia, contralateral movement disorder (hyperkinesis)

Oculomotor Nucleus

Composed of several subnuclei

Caudal Central Nucleus-> levator

nucleus is on the midline

neurons for both sides are mixed

lesion here is <u>bilateral</u>

Edinger-Westphal nucleus-> pupil & lens

Close to midline

Extent of mixing is uncertain

lesion here is often bilateral

Dorsal Nucleus & Ventral Nucleus

Have mixture of IO, SR, MR, IR

Superior Rectus is controlled contralaterally, with fibers crossing immediately into nucleus on the opposite side, to emerge with ipsilateral control fibers.

Warwick's division of III Nucleus (fig)

Trochlear Nerve (IV)

Controls only Superior Oblique

Very thin nerve

Emerges from brainstem dorsally

Fascicle of IV

Fibers decussate to form contralateral nerve

very short, rare to have focal lesion in fascicle

Nucleus of IV

Located at caudal end of Oculomotor Nucleus III, near Inferior Colliculus

Controls contralateral Superior Oblique

Abducens Nerve (VI)

controls Lateral Rectus

Longest coarse, prone to injury from trauma

Fascicle of VI

Fibers pass ventrally near superior olive, facial nucleus and motor nucleus of trigeminal nerve

Lesion here often is accompanied by other neurological signs, such as facial palsy, which differentiate from nerve damage.

Nucleus of VI

Neurons project to ipsilateral Lateral Rectus

Interneurons also project to contralateral Oculomotor Nucleus for control of contralateral Medial Rectus, producing yoked movements on lateral gaze.

Premotor role of Abducens nucleus

Nucleus of VI has both motor and premotor neurons, because interneurons for controlling contralateral medial rectus innervate motor neurons in contralateral nucleus of III.

Abducens can be thought of as a **gaze center** for horizontal version, because it provides yoking of ipsi LR and contra MR This embodies Hering's Law of Equal Innervation.

Fibers decussate and ascend through **Medial Longitudinal Fasciculus,** an important fiber pathway near midline that also carries vestibular and other signals.

Lesion in **MLF** affecting interneurons from the abducens nucleus produces **InterNuclear Ophthalmoplegia (INO)**, a paralysis of aDduction during attempted version. Convergence is often spared.