3RD, 4TH AND 6TH CRANIAL NERVE PALSIES

AUTHORS

Anand Moodley: Department of Neurology, University of KwaZulu Natal

PEER REVIEWER

Leonard Messner: Illinois College of Optometry

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3RD, 4TH AND 6TH CRANIAL NERVES

The 3rd, 4th and 6th cranial nerves control the upper lid and eye movements (Figure 3.1). They follow a long intracranial course.
The superior oblique receives its innervation from the 4th cranial nerve, the trochlear nerve. The lateral rectus receives its innervation from the 6th cranial nerve, the abducens nerve. The medial rectus, inferior rectus, inferior oblique and superior rectus are all innervated by the 3rd cranial nerve, the oculomotor nerve. The levator palpebrae superioris is also innervated by the 3rd cranial nerve.

SO4 LR6 R3 is a useful mnemonic to help remember the innervations of the extra-ocular muscles.

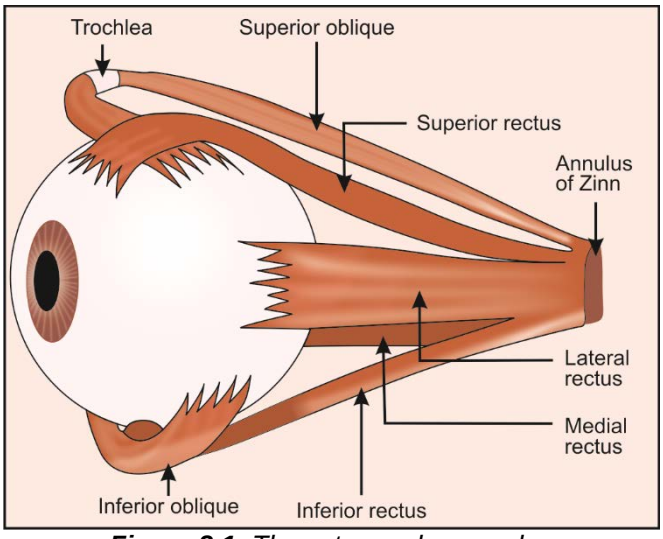

Figure 3.1: *The extra-ocular muscles*

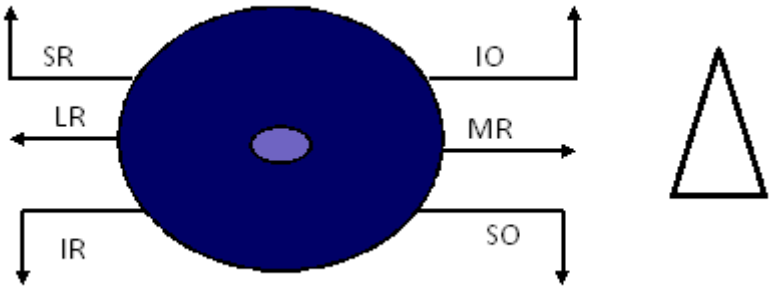

Figure 3.2*: Diagnostic action of extra-ocular muscles*

HOW DO WE TEST THE MUSCLES?

The above diagram (Figure 3.2) shows the direction of eye movements required to test the function of the different extra-ocular muscles. Testing of the medial rectus involves adduction of the eye. Testing of the lateral rectus involves abduction of the eye. Testing of the elevators and depressors involves abduction or adduction before elevating or depressing the eye to allow for alignment of the globe in the direction of the tested muscle. For the inferior oblique, the eye has to be adducted then elevated. For the superior oblique, the eye has to be adducted then depressed. For the superior rectus, the eye has to be abducted then elevated. For the inferior rectus, the eye has to be abducted then depressed.

3RD NERVE – OCULOMOTOR NERVE

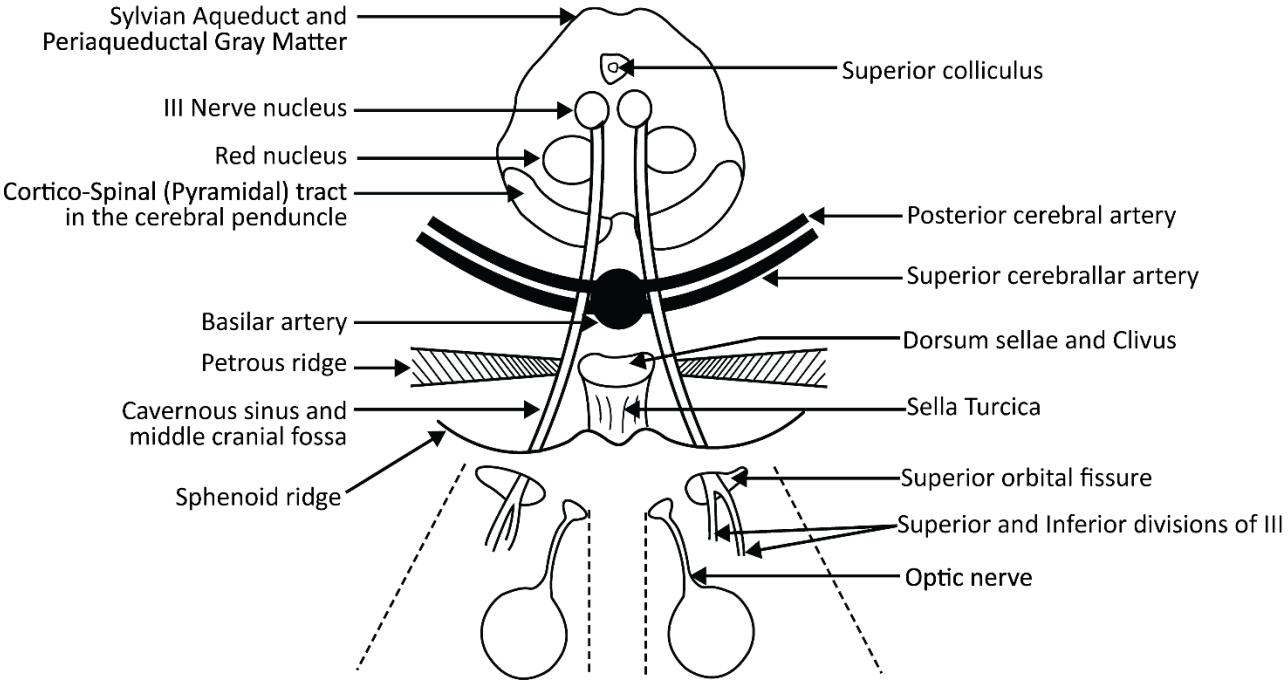

Figure 3.3: *The 3rd nerve from the Nucleus in midbrain to the orbit*

The oculomotor nerve nucleus lies in the midbrain in the peri-aqueductal grey matter (Figure 3.3). The nerve fascicles (axons that arise from the nucleus) pass through the red nucleus. The nerve emerges from the midbrain between the cerebral peduncles, then lies between the posterior cerebral artery and superior cerebellar artery. It runs parallel to the posterior communicating artery and then enters the cavernous sinus (venous structure at base of the skull). The 3rd, 4th and 5th cranial nerves (ophthalmic division) run within the lateral wall of the cavernous sinus and can therefore be simultaneously involved in cavernous sinus lesions. The nerve thereafter enters the orbit through the superior orbital fissure and divides into 2 main divisions: upper (superior) and lower (inferior). The upper division supplies the:

- Eyelid
- Superior rectus muscle

The lower branch supplies the:

- Medial Rectus
- Inferior Rectus
- Inferior Oblique
- Pupil

3RD N PALSY

A third nerve palsy presents with 5 D's:

- Diplopia
- Divergent Squint (exotropia)
- Droopy Eyelid
- Dilated Pupil
- Decreased near vision

A third nerve palsy presents with complete ptosis.
Pupil sparing 3rd N palsy suggests a non-compressive cause. Pupil fibers are superficial and are not affected by ischaemia to the nerve from the vasa nervorum. Blood supply to pupillary fibers is from surrounding adventitia.
Figure 3.4 shows the 9 cardinal positions of the eye in a patient with isolated Right 3rd nerve palsy. The contralateral eye to the nerve palsy is exotropic (due to intact 6th nerve) and downwardly displaced (due to intact 4th nerve).

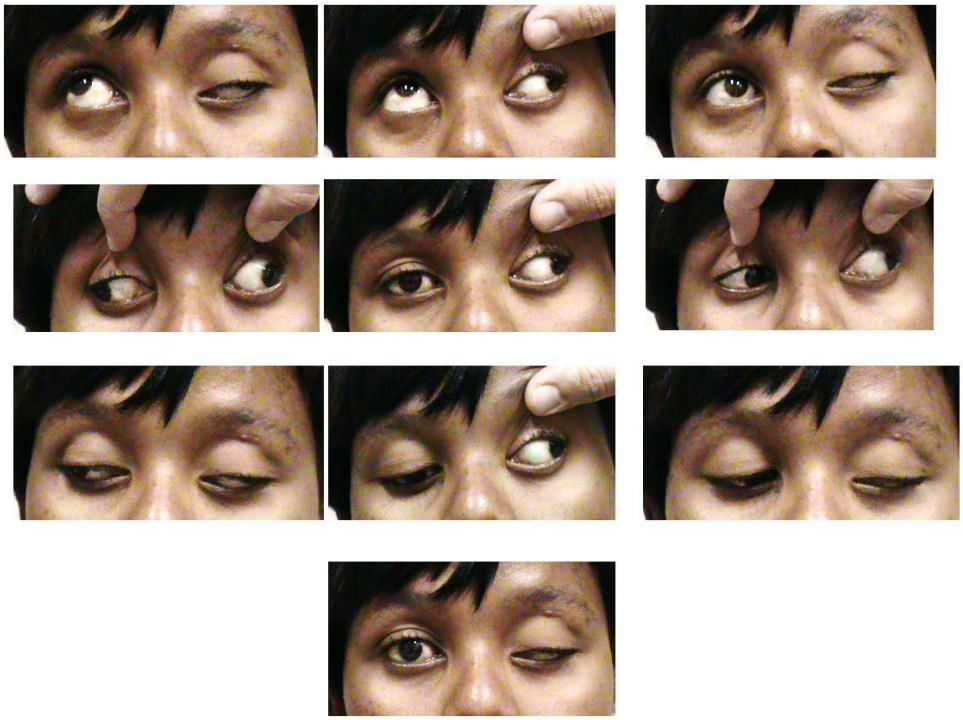

***Figure 3.4**: The 9 cardinal positions of the eye demonstrating a patient with isolated Right 3rd nerve palsy.*

CAUSES OF ISOLATED 3RD NERVE PALSY

- Ischaemic (from Diabetes Mellitus)
- Aneurysmal compression (look for pupil enlargement)
- Trauma
- Tumour (check for aberrant regeneration)
- Infection
- Inflammation
- Idiopathic

4TH NERVE – TROCHLEAR NERVE

The supra-nuclear control is entirely crossed. The nucleus lies in (midbrain) dorsum of brainstem and the fibers decussate (cross over) around the peri-aqueductal grey matter in the superior medullary velum (Figure 3.5). The right nerve originates in the left trochlear nucleus. It has a long intracranial course and also enters the cavernous sinus. It enters the roof of the superior orbital fissure and crosses the 3rd nerve. This nerve supplies just one muscle—the superior oblique muscle.

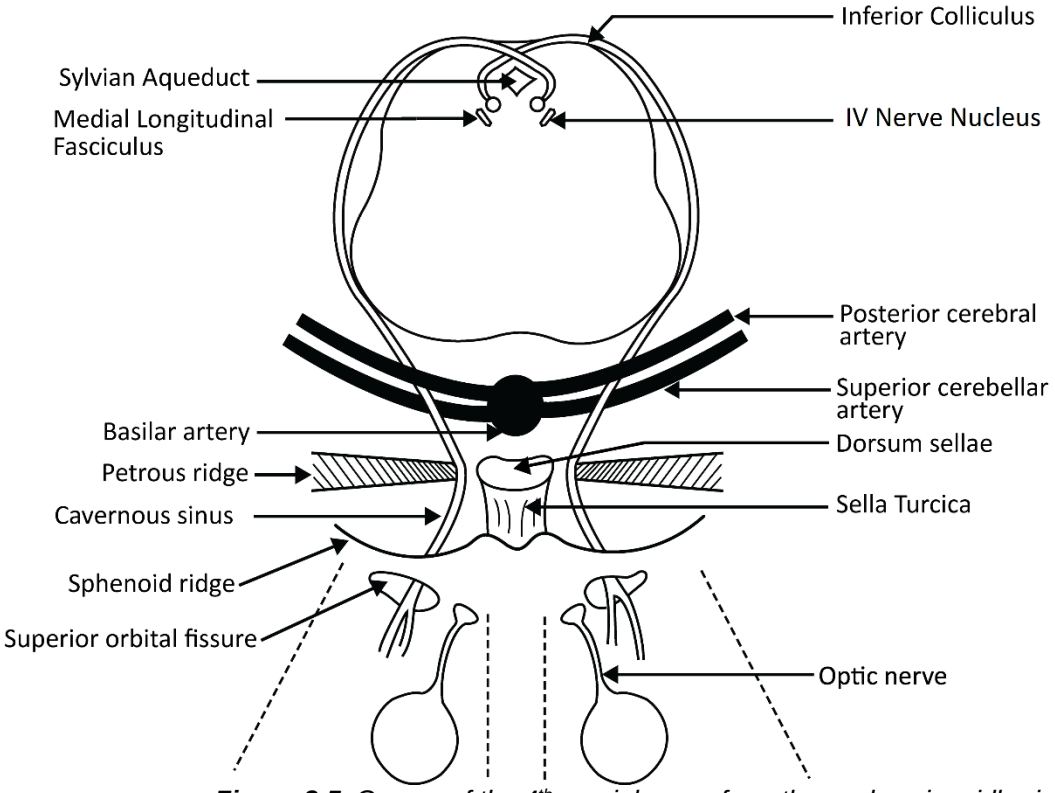

***Figure 3.5**: Course of the 4th cranial nerve from the nucleus in midbrain to the orbit*

4TH NERVE PALSY

Weakness of the superior oblique muscle will result in vertical diplopia. One image is slightly rotated with an oblique orientation. The eye rotates slightly outwards and the superior rectus slightly elevates the eye. The eye with the weak muscle is therefore hypertropic. A compensatory head tilt away from the lesion is adopted to line up with the vertical image from the normal eye (head tilt in the opposite direction). (Figure 3.6)

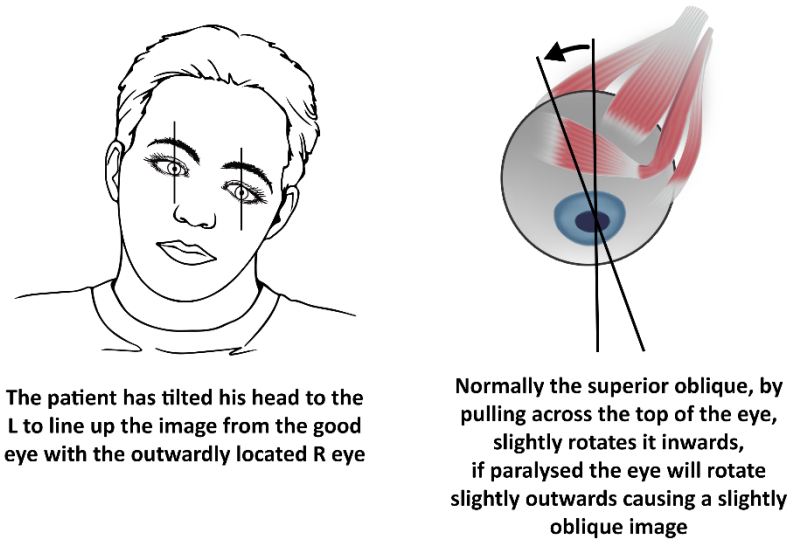

***Figure 3.6**: 4th nerve palsy compensatory head tilt*

The 3 step Parks Bielchowsky Test is used to diagnose an isolated 4th nerve palsy:

Step 1 – Identify the hypertropic eye. The ipsilateral IR or SO are weak or the contralateral IO or SR are weak

Step 2 – Determine the direction in which lateral gaze causes the greatest separation. The greatest separation occurs in the direction of the weak muscle. For greater right hypertropia on left gaze means either the right SO or left SR are weak. For greater right hypertropia on right gaze means either the right IR or left IO are weak. The reverse is applicable for left hypertropia on step1.

Step 3 – Tilt the head to the right and left. The greater separation will occur on right tilt if it's right SO weakness or on left tilt if it's left SR weakness for right hypertropia on step 1.

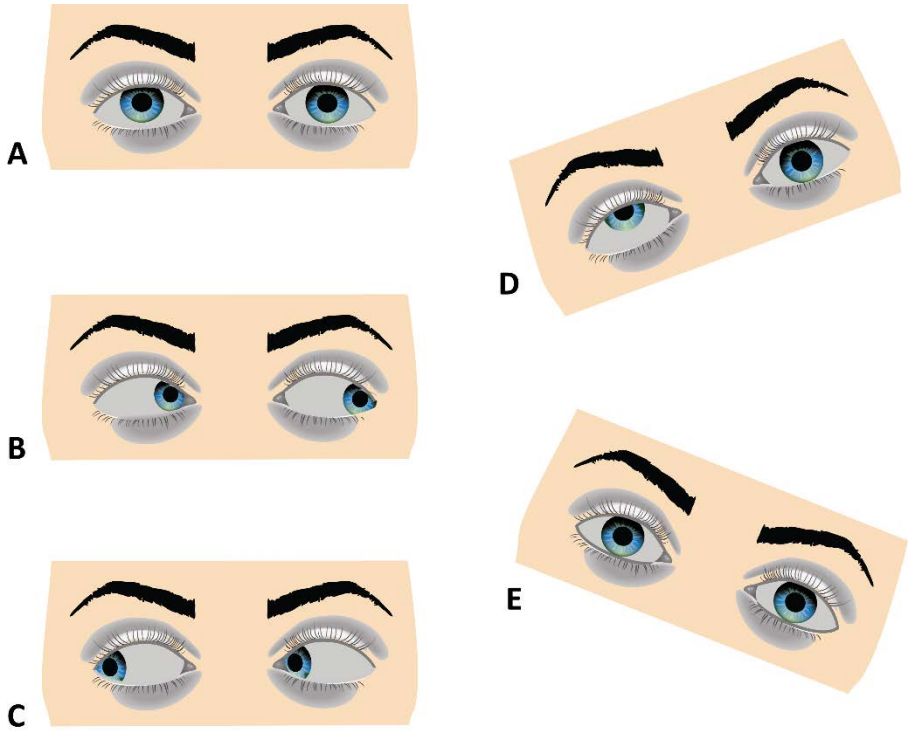

***Figure 3.7:** Right hypertropia*

The above picture illustrates an example of a right hypertropia (Figure 3.20):

- Step 1 shows that the right hypertropia becomes worse when there is a right head tilt
- Step 2 shows that the right hypertropia is worse on left gaze

This therefore implies a right superior oblique weakness.

ISOLATED 4TH NERVE PALSIES

- Trauma
- Ischaemia
- Masses (along the clivus).
- Idiopathic
- Congenital – most common, probably due to birth trauma

6TH NERVE – ABDUCENS NERVE

This nerve arises from the front of the ponto-medullary junction. The nucleus lies in the pons. It ascends on the front of the pons and angles forwards over the tip of the petrous bone into Dorello's Canal and thereafter enters the cavernous sinus (Figure 3.8). The abducens nerve lies free in the cavernous sinus and enters the orbit via the superior orbital fissure to supply the lateral rectus muscle. The sharp bend of the nerve into Dorello's canal makes it susceptible when there is downward displacement of the brainstem from raised intracranial pressure. The result is a false localizing 6th nerve palsy.

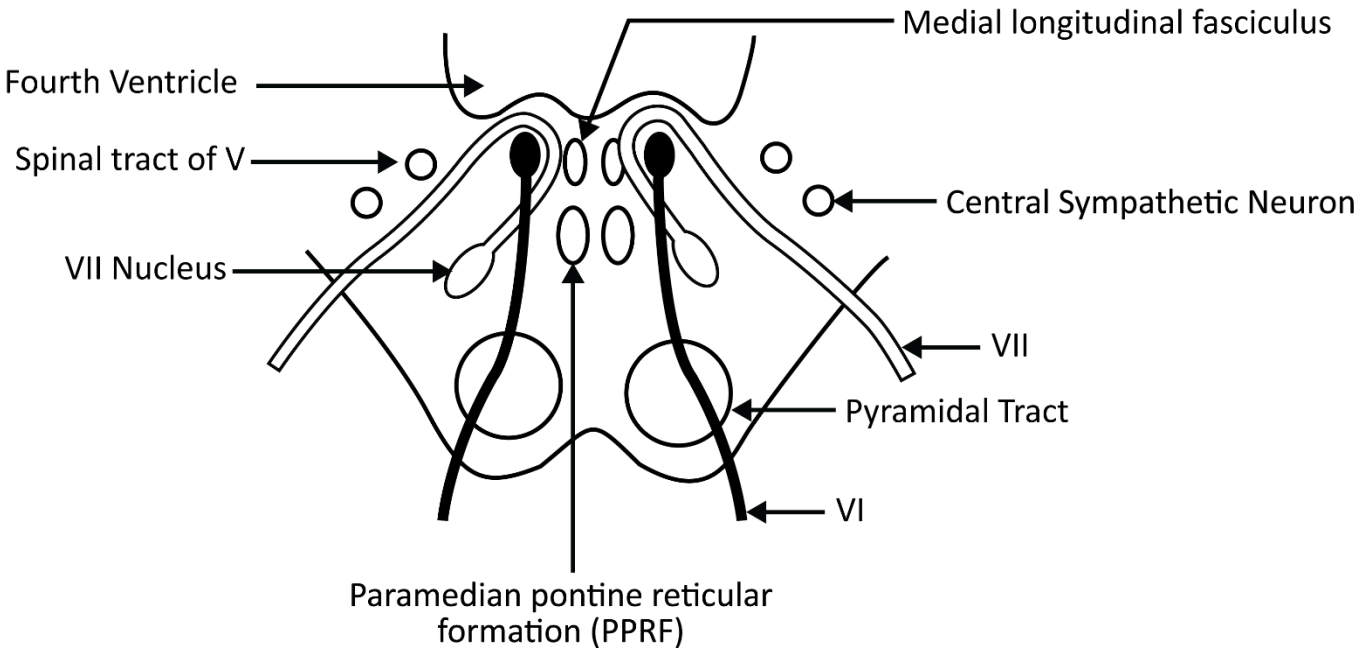

***Figure 3.8**: Course of the 6th nerve from the nucleus in the pons to the orbit where it supplies the lateral rectus muscle*

6TH NERVE PALSY

A sixth nerve palsy results in:

- Horizontal diplopia
- Convergent squint (Figure 3.23)

A compensatory head turn toward the weak muscle is adopted.

ISOLATED 6TH NERVE PALSY

- Idiopathic
- Ischaemic
- Traumatic
- Inflammation
- Tumour
- Cavernous sinus thrombosis
- Cryptococcal / Tuberculosis (TB) meningitis: common causes of bilateral 6th nerve palsy

ANATOMICAL BASIS FOR CN LESIONS

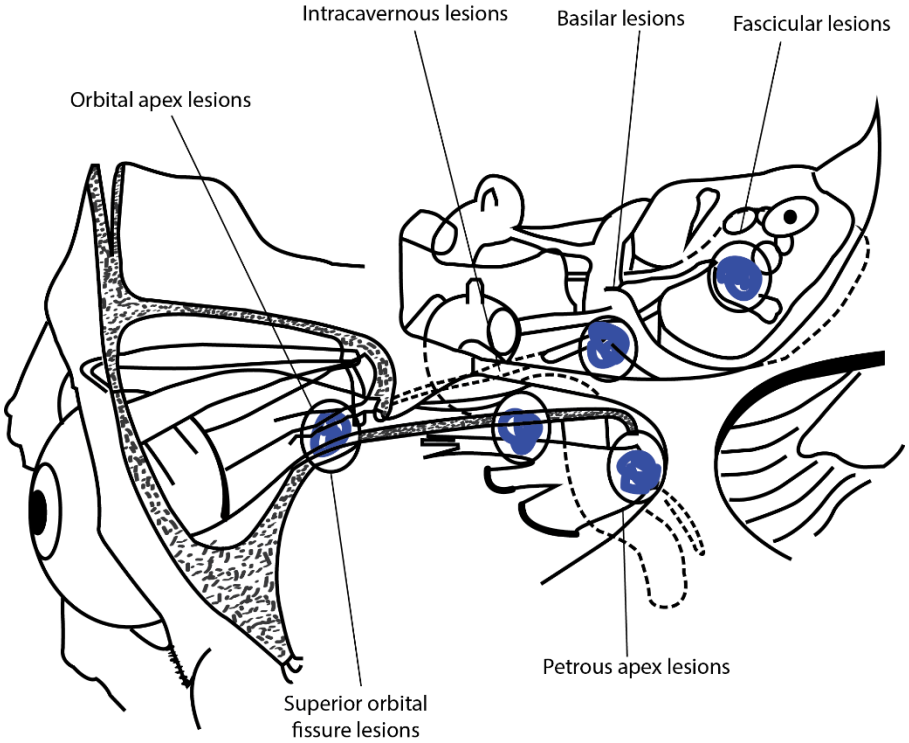

***Figure 3.9**: Location of cranial nerve lesions*

CAUSES OF EXTRAOCULAR NERVE LESIONS

Nuclear and Fascicular lesions

- Named syndromes; Weber (ipsilateral 3rd and contralateral hemiparesis), Claude (ipsilateral 3rd and contralateral ataxia), Benedikt (ipsilateral 3rd and contralateral tremor), Millard-Gubler (ipsilateral 6th and contralateral hemiparesis)
- Strokes, Multiple Sclerosis, Pontine Glioma, Wernicke's Encephalopathy-Thiamine deficiency

Basilar Area

- Basal Meningitis: TB, Fungal, Bacterial
- Carcinomatous Meningitis
- Syphilis, Sarcoidosis
- Posterior communicating artery aneurysm
- Temporal lobe herniation

Petrous Tip

- Mastoiditis - Gradenigo's Syndrome (ipsilateral 6th and 5th cranial nerve palsies)
- Lateral sinus thrombosis
- Nasopharyngeal Carcinoma

Cavernous Sinus

- Cavernous sinus thrombosis
- Intrasellar Tumour, Pituitary tumour
- Carotid Aneurysm
- Carotico-cavernous fistula
- Meningiomas, chordomas
- Mucocoeles
- Nasopharyngeal Carcinoma, Craniopharyngioma

Superior Orbital Fissure and Orbit

- Tumours of the orbit
- Pseudotumour of the orbit / Tolosa Hunt syndrome
- Dermoid, neurofibroma
- Angiomas, Haemangiomas
- Arterio-venous malformations

If the third, fourth and sixth nerves and the ophthalmic division of the fifth nerve occur together, consider a cavernous sinus problem or an orbital apex syndrome. An orbital apex syndrome will also have optic nerve involvement.

Aberrant re-innervation: due to a slow growing tumor or a regenerating 3rd nerve: when looking medial or down, the lid moves up or the pupil constricts.

CRANIAL NERVE REVIEW & TESTING TABLE

(Remember: On **O**ld **O**lympus **T**owering **T**op **A F**amous **V**ocal **G**erman **V**iewed **S**ome **H**ops)

#	Cranial Nerve Name	Foramen + (Region Entered)	Components	Target + Function	Testing
I	Olfactory	cribriform plate of ethmoid (nasal cavity)	special sensory	Olfactory epithelium (smell)	• Check patency of each side • Identification of common substances (non-noxious products e.g. coffee, peppermint, cloves) • Note if different for each side
II	Optic	optic canal of sphenoid (orbit)	special sensory	Retina (vision)	~ OD'S ALLEY ~
III	Oculomotor	superior orbital fissure (orbit)	somatomotor	Levator palpebrae superioris; superior, medial, inferior recti; inferior oblique	~ OD'S ALLEY ~
			visceromotor	Preganglionic parasympathetic to ciliary ganglion (sphincter pupillae & ciliary muscle)	~ OD'S ALLEY ~
IV	Trochlear	superior orbital fissure (orbit)	somatomotor	Superior oblique muscle	~ OD'S ALLEY ~

V	V1-Trigeminal ophthalmic (Major branches: Lacrimal, Frontal, Nasociliary, Meningeal)	superior orbital fissure (orbit)	general sensory	General sensation from skin and mucosa in region at and above orbit	• Test each separately innervated region for light touch and pain using a cotton wisp from a cotton tipped applicator and a safety pin or paper clip • In testing for pain, alternate between sharp and dull end asking patient to indicate sensation of pain • Test randomly, both sides • Keep patient eyes closed • Note asymmetry or reduced sensation
	V2-Trigeminal maxillary (Major branches: Infraorbital, Zygomatic, Nasopalatine, Palatine)	foramen rotundum (pterygopalatine fossa)	general sensory	General sensation from skin and mucosa in region from orbit to mouth	
	V3-Trigeminal mandibular (Major branches: Auriculotemporal, Buccal, Lingual, Inferior Alveolar, Meningeal)	foramen ovale with lesser petrosal from CN9 (infratemporal fossa)	general sensory	General sensation from the skin and mucosa from region at and below the mouth	
			branchiomotor	Muscles of mastication tensor tympani tensor veli palatini mylohyoid anterior belly digastric	• Palpate muscle mass bilaterally while teeth are clenched • Observe side-to-side movement of jaw while pushed forward with open mouth • Note deviation, asymmetry, inability
VI	Abducens	superior orbital fissure (orbit)	somatomotor	To lateral rectus	~ OD'S ALLEY ~
VII	Facial (Major motor branches: Temporal, Zygomatic, Buccal, Mandibular, Cervical, Posterior	Internal acoustic meatus → facial canal → stylomastoid foramen (temporal bone)	branchiomotor	Muscles of facial expression stapedius stylohyoid mylohyoid posterior belly digastric	• Have patient smile, frown, furrow the brow, pucker the lip • Have patient close eyes tight and resist forced opening • Note deviations, weaknesses

	Auricular)				
		facial canal → middle ear → chorda tympani → petrotympanic fissure	special sensory	Taste, anterior 2/3 tongue	• Test using a pinch of salt & sugar • Place on protruded tongue • Have patient point at answer signs • Rinse mouth between stimuli
		Facial canal → middle ear → chorda tympani → petrotympanic fissure	visceromotor	Preganglionic parasympathetic to: submandibular ganglia (innervates submandibular and sublingual glands)	
		Greater superficial petrosal → pterygoid canal	visceromotor	Preganglionic parasympathetic to: pterygopalatine ganglia (innervates lacrimal gland, nasal glands, and palatine glands)	• Lacrimal function tested in dry eye test battery
VIII	Vestibulocochlear	Internal auditory meatus (temporal bone)	special sensory	Hearing and balance	• Hold ticking watch or rub fingers moving them away until sound is not heard • Compare distance right and left ear • If difference exists, differentiate conductive vs. neural loss using: • Weber Test Hold a 256 Hz tuning fork at vertex of skull. Ask patient for sound direction – should be midline. With conductive hearing loss, background noise is attenuated and bone acts like major conductor, so sound direction localizes to abnormal ear • Rinne Test

					Compare bone & air conduction on right and left sides. Hold the vibrating fork on mastoid and ask patient when sound is gone. Then move fork to ear. If sound also gone – loss is conductive If sound persists – loss is neural
IX	Glossopharyngeal	Jugular foramen (neck)	branchiomotor	Stylopharyngeus	• IX & X tested together because of proximity of motor & sensory nerves
			viscerosensory	Pharynx, palate, carotid sinus, carotid body and posterior 1/3 tongue	• Inquire about voice quality, changes • Examine oropharynx with tongue depressor while patient says “Ahhh” • Assess symmetry of movement of soft palate, uvula, and inward movement of posterior pharynx • Test for gag reflex on each side of back of throat (nasopharyngeal area) • Check for ease of swallowing
		Jugular foramen → tympanic branch → tympanic caniculus → middle ear (middle ear)	viscerosensory	Middle ear and auditory tube	
		Jugular foramen → tympanic branch → tympanic caniculus → middle ear (infratemporal fossa)	visceromotor	Parotid	
X	Vagus	Jugular foramen	branchiomotor	Pharynx and larynx	• See testing for IX above
			general sensory	Auricle, external auditory meatus	
			viscerosensory	Mucosa of entire larynx	
			visceromotor	Preganglionic	

				parasympathetic to abdomen & thorax	
XI	Spinal Accessory	Enters by foramen magnum → exits by jugular foramen (neck)	branchiomotor	Trapezius, sternocleidomastoid	• Have patient shrug shoulders • Have patient turn head against your resistance • Compare relative strength of right and left sides
XII	Hypoglossal	Hypoglossal canal (neck)	somatomotor	All tongue muscles (these end in 'glossus') are innervated by CN12 except palatoglossus	• Have patient stick tongue straight out, curve it upward and downward. • Have patient push tongue against inside of his cheek while you push against it • Note difficulties, deviations, unequal resistance

Drawn & modified from various resources including: *neuro714@macc.wisc.edu* & Rosenow P.R et al. Your Expanded Role. Review of Optometry 1998;(11) 76-87.