

Lecture Title:

BRAIN STEM AND RELATED CRANIAL NERVES..

(NEUROPSYCHIATRY BLOCK, Radiology)

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Lecture Objectives..



Students at the end of the lecture will be able to:

- Identify radiological anatomy of brain stem.
- Compares CT and MRI imaging of brain stem.
- Identify MRI imaging anatomy of cranial nerves.

Brain Divisions..



- There are three major divisions of the brain:

I Prosencephalon **Forebrain**

Diencephalon thalamus, hypothalamus

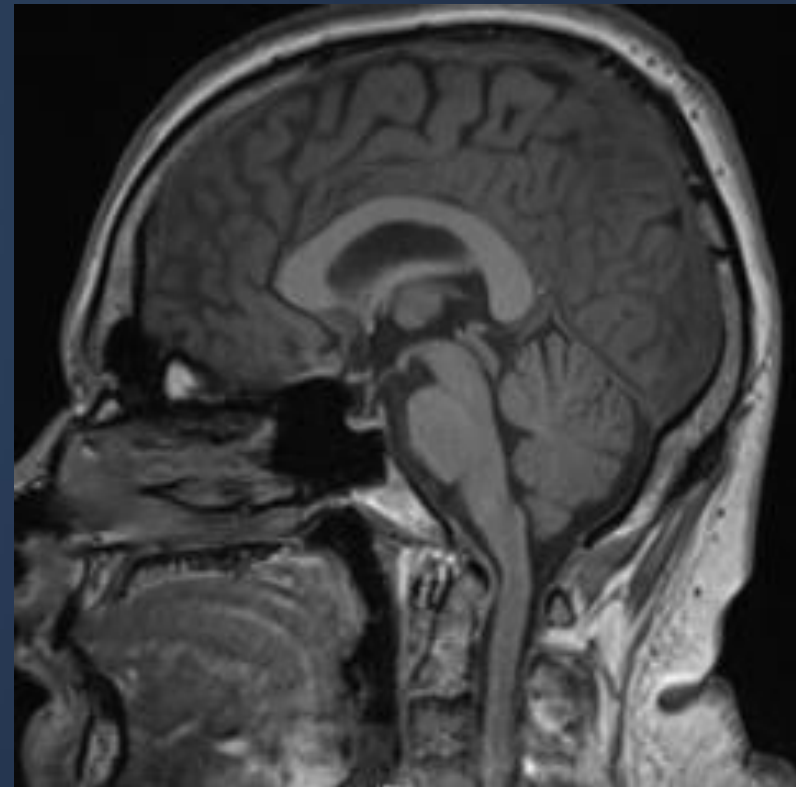
Telencephalon cerebrum

II Mesencephalon – **Midbrain**

III Rhombencephalon - **Hindbrain**

Metencephalon pons and cerebellum

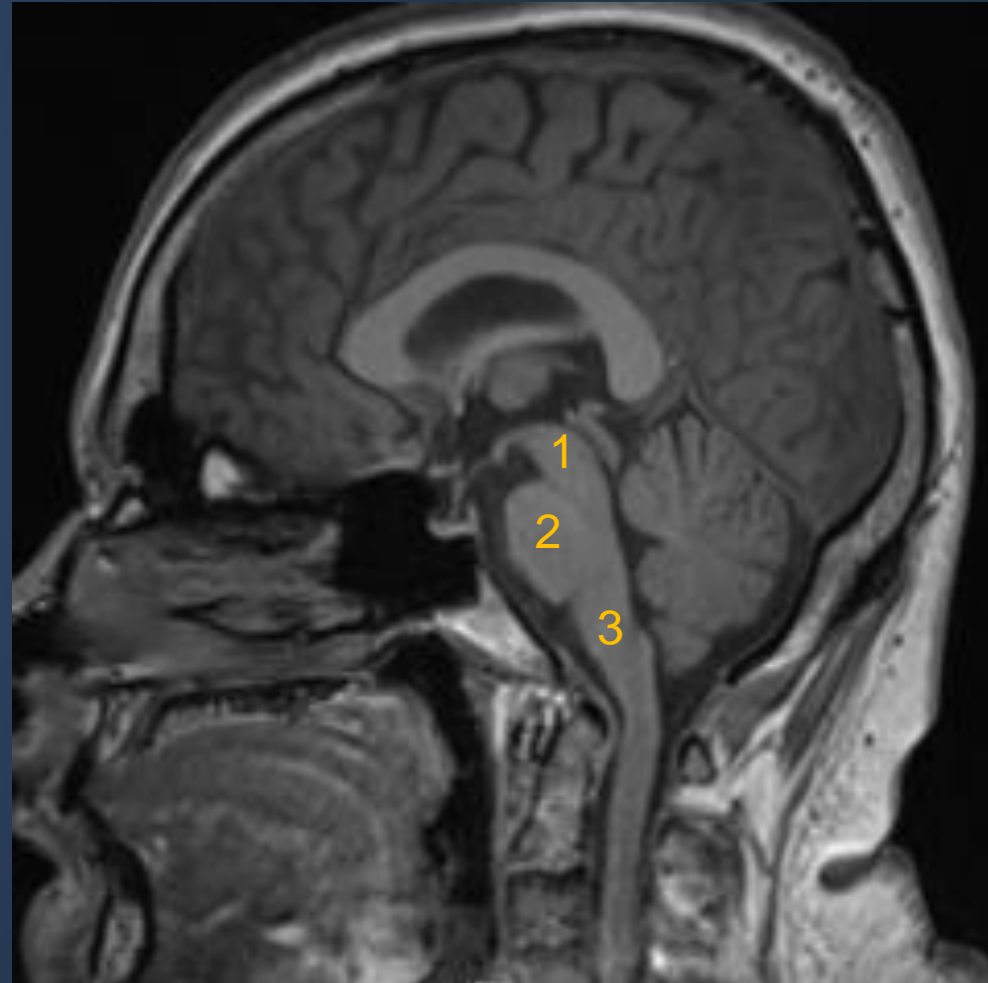
Myelencephalon medulla oblongata



Brain Stem..



- Three parts from superior to inferior:
 - 1 midbrain
 - 2 pons
 - 3 medulla oblongata
- Connects cerebral hemisphere with spinal cord

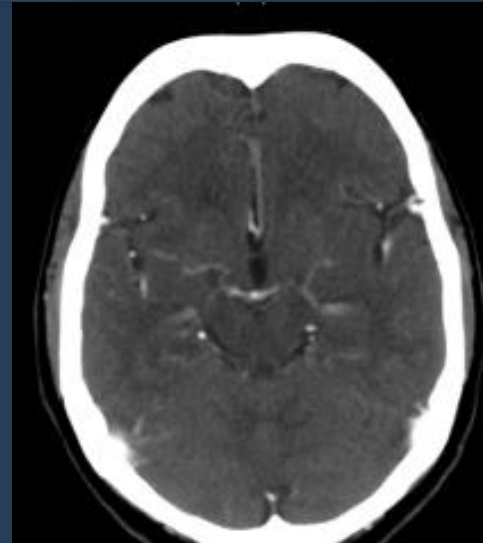


Midbrain..

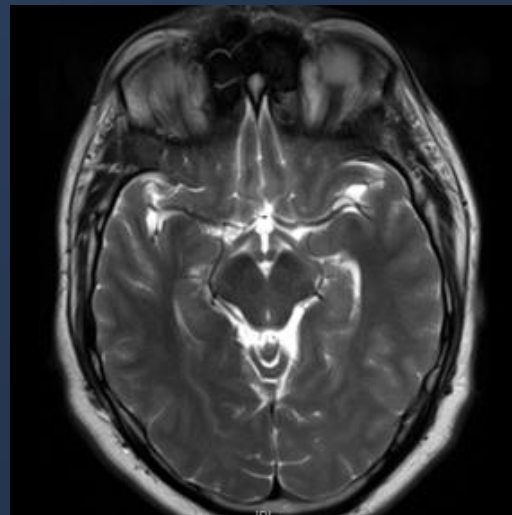


Radiological Features:

- At the level of circle of willis
- Anteriorly two cerebral peduncles separated by interpeduncular fossa
- Posteriorly four rounded prominences (superior and inferior colliculi)



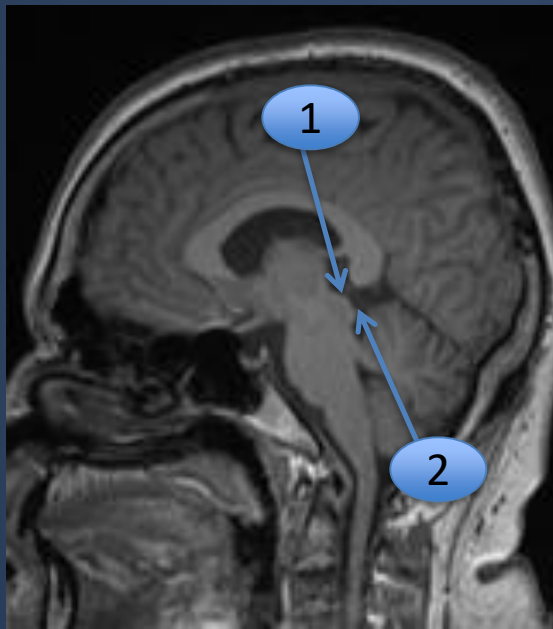
CT+



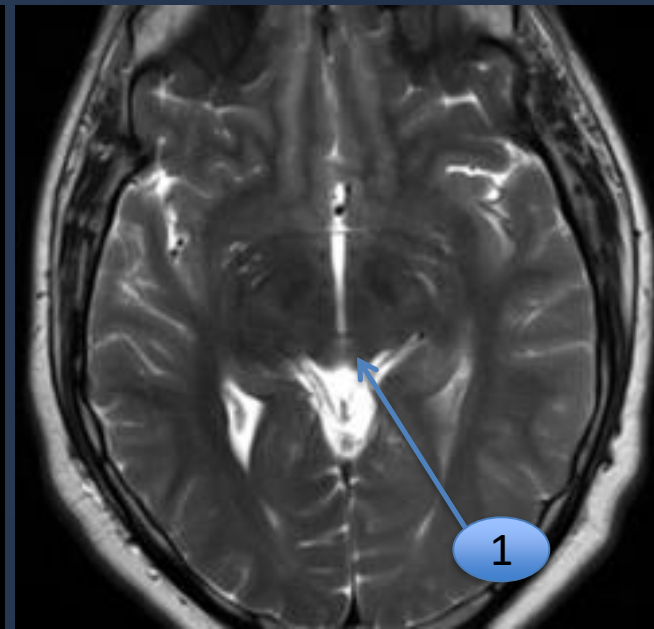
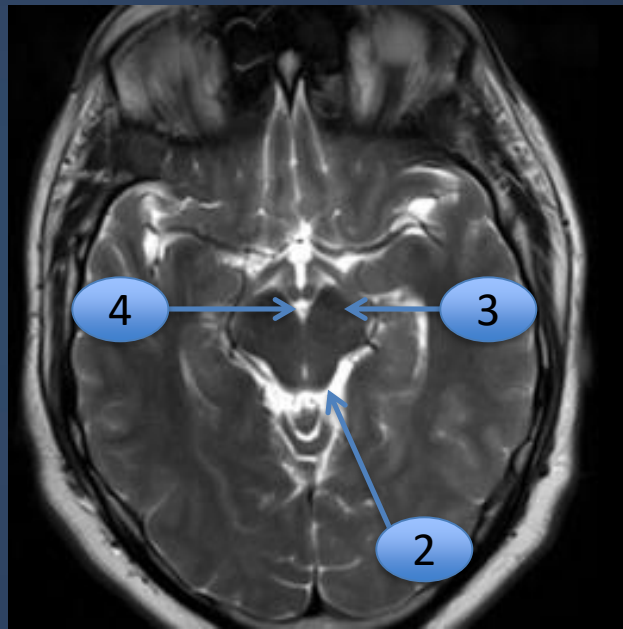
MRI
T2WI

Midbrain..

MRI Sagittal T1WI



MRI axial T2WI



- 1 superior colliculus
- 2 inferior colliculus
- 3 cerebral peduncle
- 4 interpeduncular cistern

Midbrain..

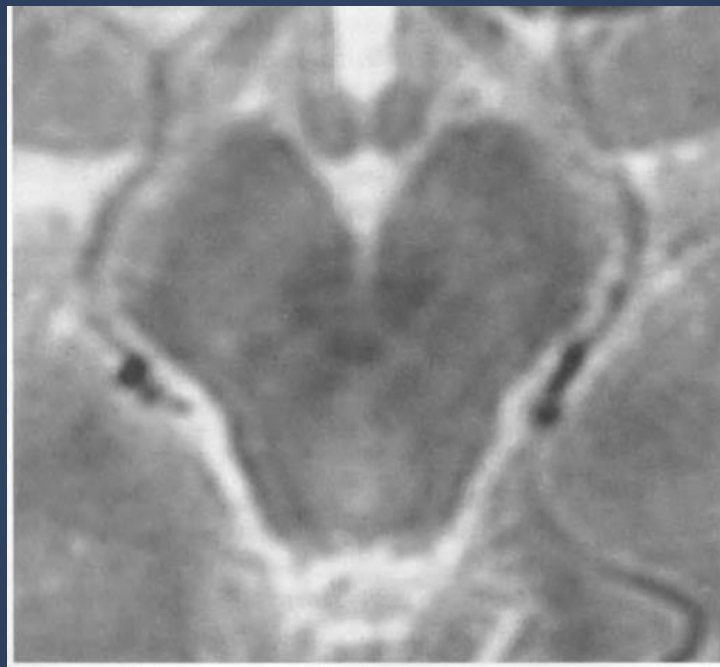
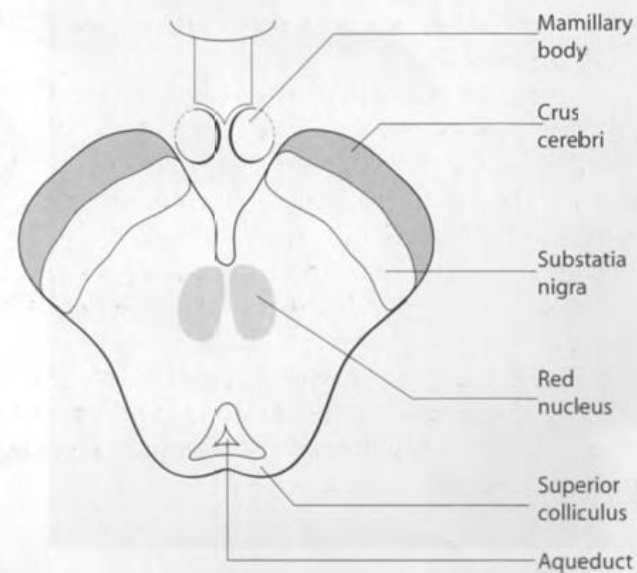


Fig. 2.14 Midbrain, axial section: (a) T₂ MRI; (b) diagram.



Internal features:

substantia nigra separates crus cerebri ventrally from tegmentum posteriorly. Red nuclei are dorsal to substantia nigra at the level of superior colliculi

Pons..



Radiological Features:

- The bulbous anterior part consists mainly of fibres continuous on each side with middle cerebellar peduncle
- Basilar artery lies in groove anteriorly
- Posterior surface of the pons forms the upper part of the floor of the 4th ventricle.
- Bony anterior relation: clivus centrally and petrous temporal bones laterally



CT+

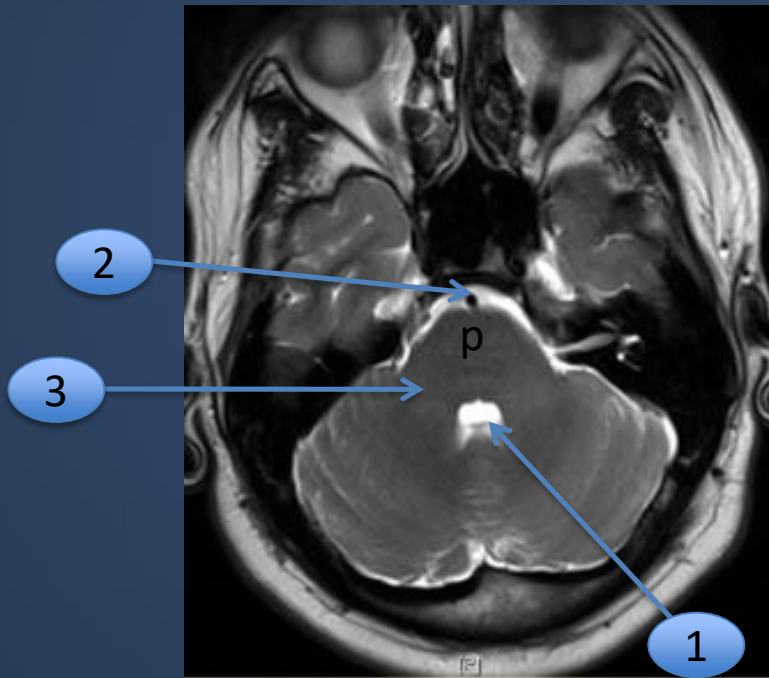
Petrous bone



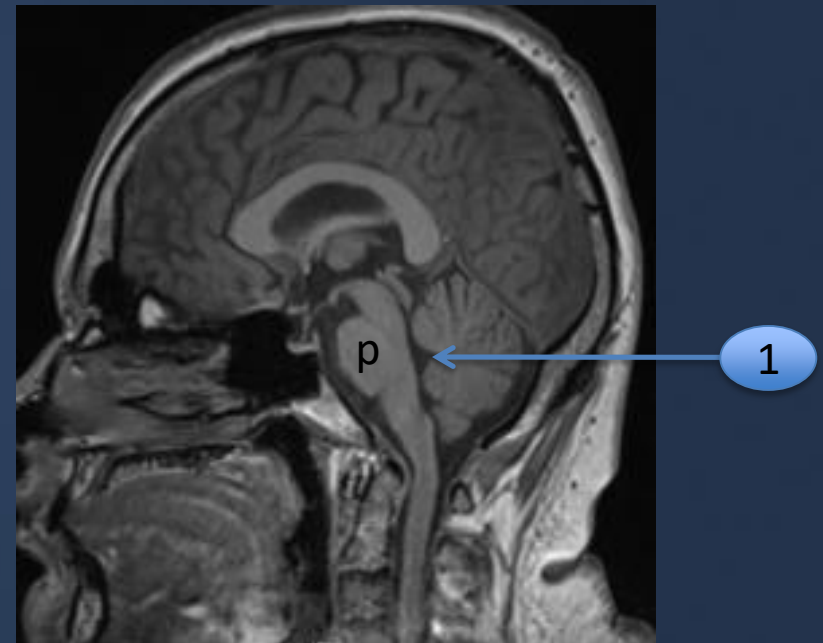
Basilar artery

Pons..

MRI axial T2WI



MRI Sagittal T1WI



P pons

1 4th ventricle

2 basilar artery

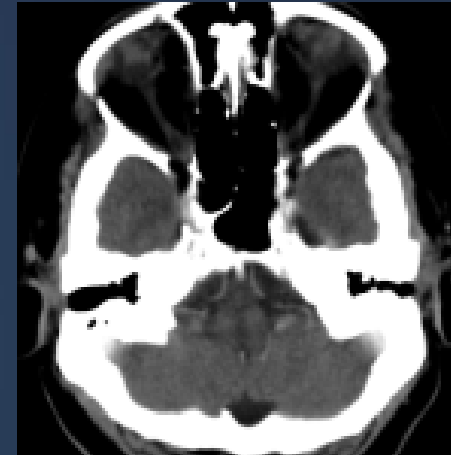
3 middle cerebellar peduncle

Medulla oblongata..

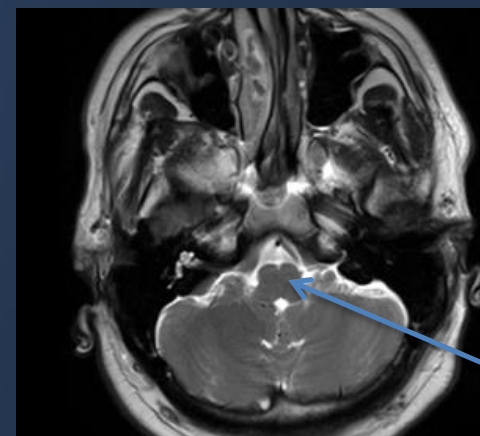


Radiological Features:

- MRI imaging of the medulla gives superior images to CT due to lack of bony artifact
- The ventral median fissure is seen anteriorly with the pyramid laterally
- The 4th ventricle is seen posteriorly



CT+



MRI axial
T2WI

medulla

MRI Imaging Anatomy of Cranial Nerves..



There are twelve cranial nerves numbered in order as they emerge from cranial to caudal in the brain:

- Olfactory (I)
 - Optic (II)
 - Oculomotor (III)
 - Trochlear (IV)
 - Trigeminal (V)
 - Abducens (VI)
 - Facial (VII)
 - Vestibulocochlear(VIII)
 - Glosopharyngeal (IX)
 - Vagus (X)
 - Accesory (XI)
 - Hypoglossal(XII).
- Not true nerves
- Arise from mid brain
- Arise from pons
- Arise from medulla oblongata

MRI Imaging Anatomy of Cranial Nerves..



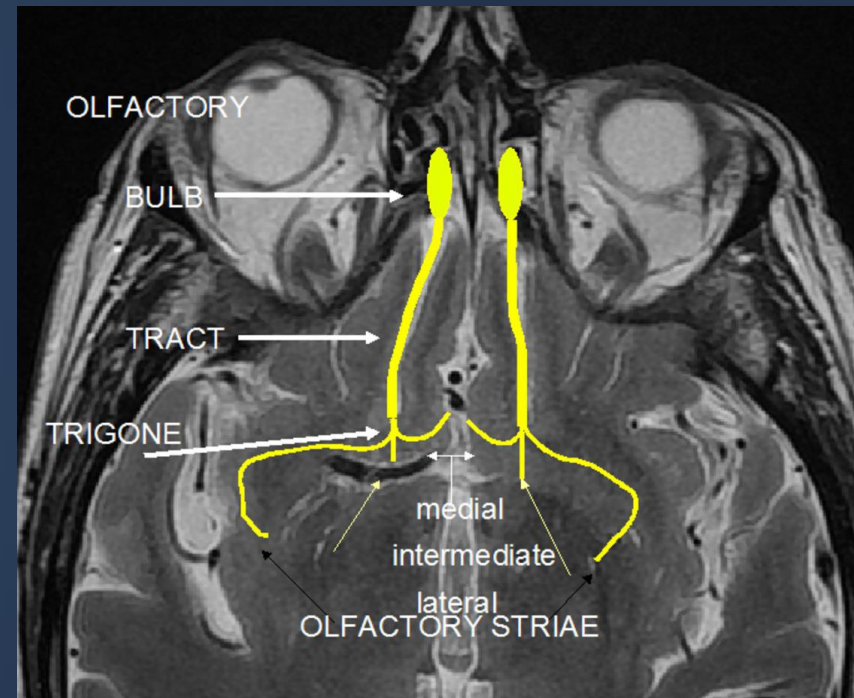
I CRANIAL NERVE = OLFACTORY NERVE

Olfactory nerve **is not a true nerve** but an extension of the brain and provides the sense of smell.

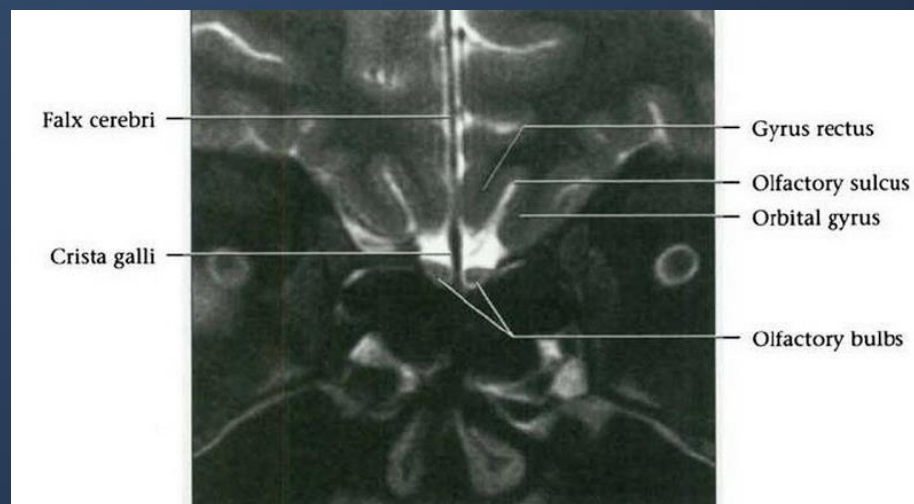
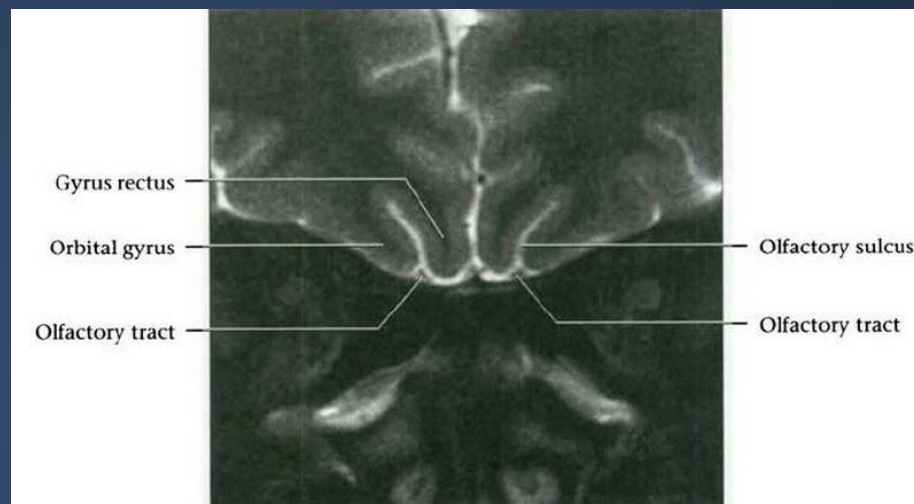
It is formed by neurosensory cells (neurons) placed in the epithelium of the nasal vault, whose axons traverse the cribriform plate, the so called transthemoidal segment.

This segment is followed by an intracranial one in the olfactory sulcus, between the gyrus rectus and the orbital gyrus; also it can be subdivided into olfactory bulb, tract and cortex.

The olfactory bulb, an enlargement of the olfactory tract, is closely apposed to the cribriform plate and is followed by the olfactory tract that, subsequently, splits into medial, intermediate and lateral stria.



MRI Imaging Anatomy of Cranial Nerves..



MRI Imaging Anatomy of Cranial Nerves..

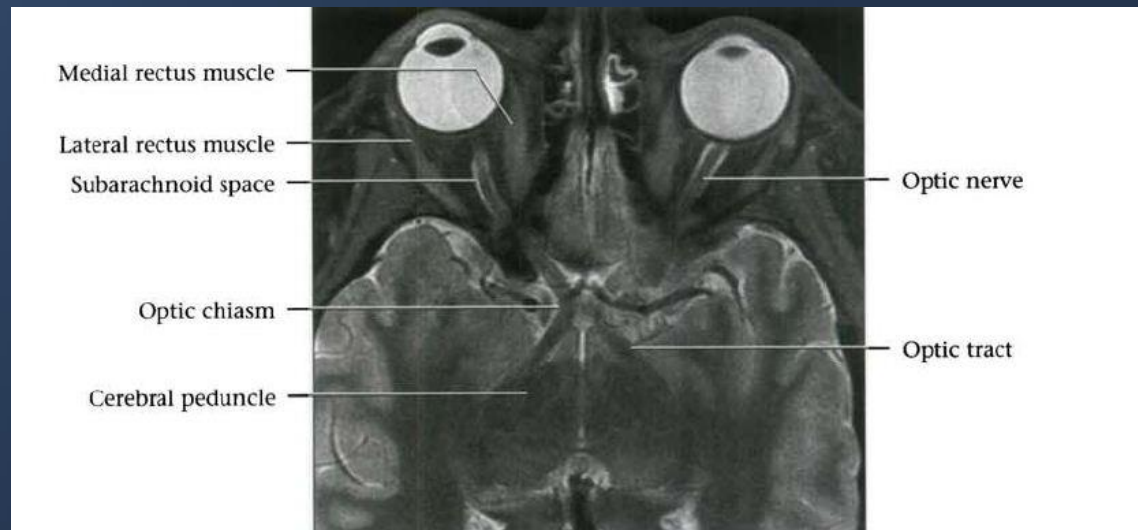


II CRANIAL NERVE = OPTIC NERVE

As well as the first cranial nerve, the optic nerve consists of the retinal ganglion cell axons, being so an extension of the brain and therefore **not a true nerve**. Both are myelinated by oligodendrocytes and not by Schwann cells as the rest of the cranial nerves, and are covered by meninges.

Optic nerve comprises four segments:

- Intraocular
- Intraorbital
- Intracanalicular
- Intracranial.



MRI Imaging Anatomy of Cranial Nerves..



III CRANIAL NERVE = OCULOMOTOR NERVE

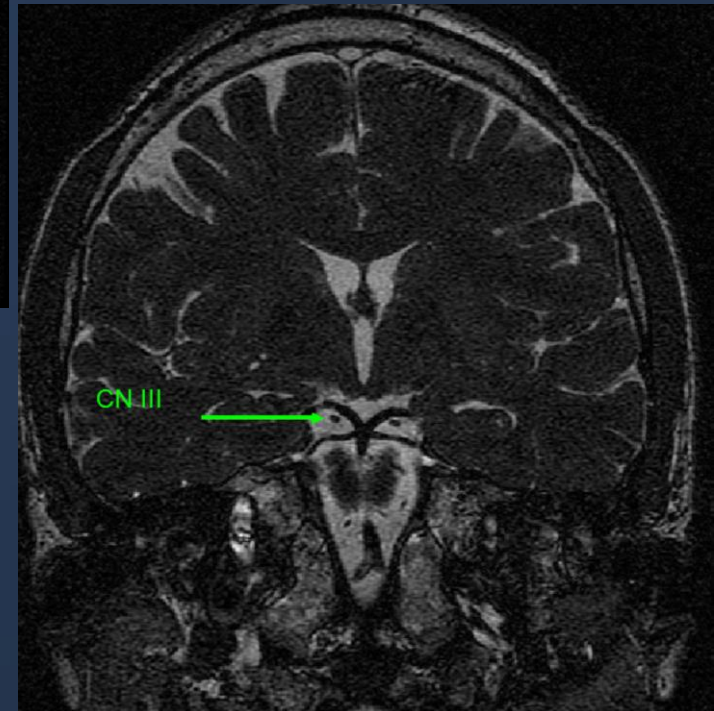
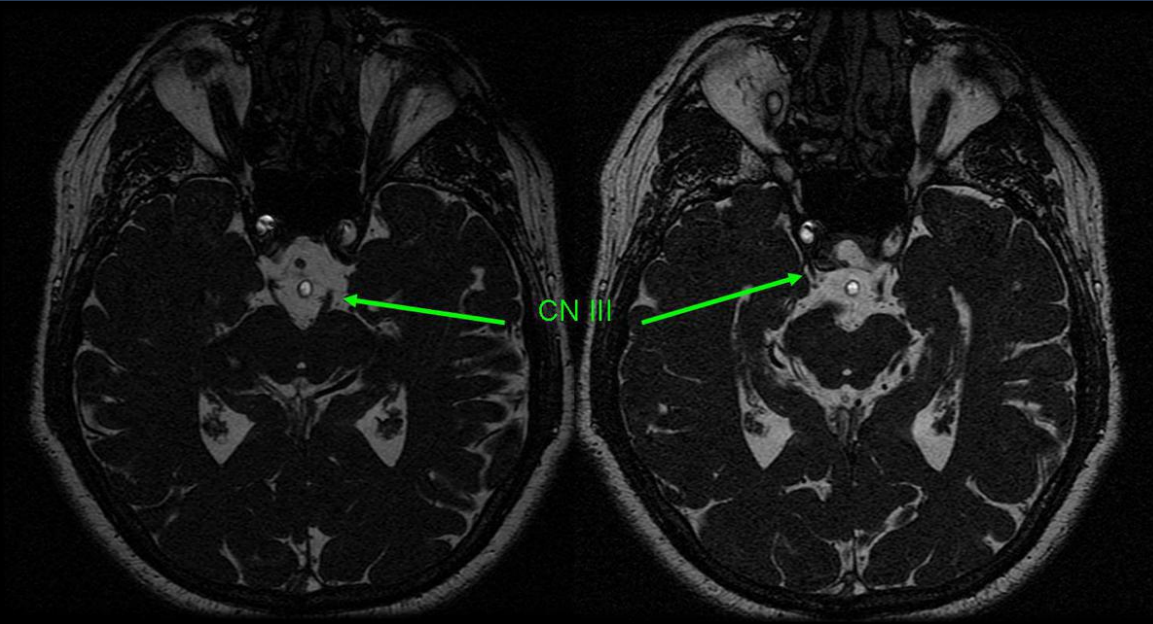
The oculomotor nerve is a mixed one: motor and parasympathetic. It consists of four parts: intraaxial, cisternal, cavernous and extracranial segments.

The third cranial nerve emerges from the mesencephalon and courses anterolaterally through the interpeduncular cistern. It passes between the posterior cerebral (cranial) and superior cerebellar (caudal) arteries.

Later on, it pierces the dura and enters the roof of the cavernous sinus.



MRI Imaging Anatomy of Cranial Nerves..



MRI Imaging Anatomy of Cranial Nerves..



IV CRANIAL NERVE = TROCHLEAR NERVE

It is a motor nerve which innervates the superior oblique muscle. Being the smallest of all cranial nerves, it is difficult to identify with MRI.

It is divided into four segments: intraaxial, cisternal, cavernous and extracranial.

The fibers exit inferior to the inferior colliculus and so it is the only cranial nerve which emerges in the dorsal aspect of the brainstem.



MRI Imaging Anatomy of Cranial Nerves..



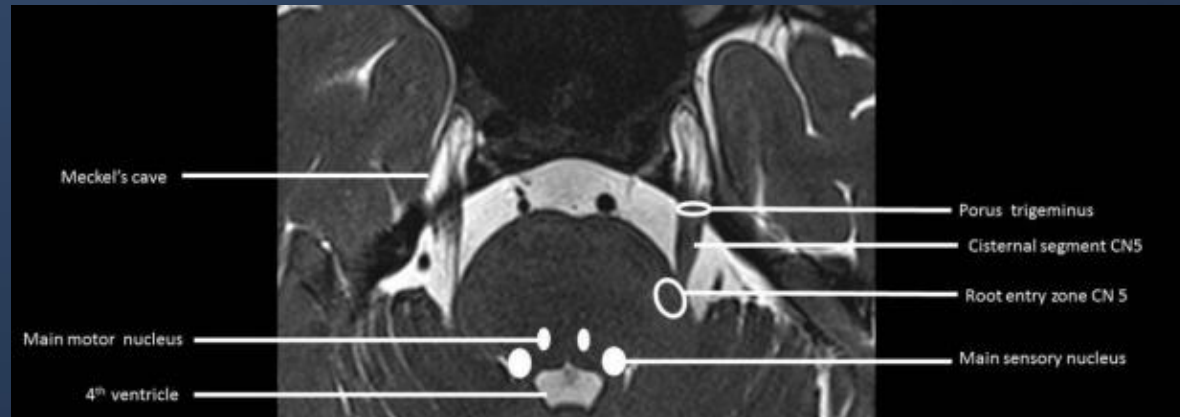
V CRANIAL NERVE = TRIGEMINAL NERVE

It is the biggest cranial nerve and is divided into a small root lateral to the big sensory one.

It has 4 segments: intraaxial, preganglionic or cisternal, interdural and post ganglionic.

INTRAAXIAL SEGMENT

The trigeminal nerve is formed by four nuclei, three sensory and one motor, which are located in the brainstem and the upper cervical cord.



MRI Imaging Anatomy of Cranial Nerves..



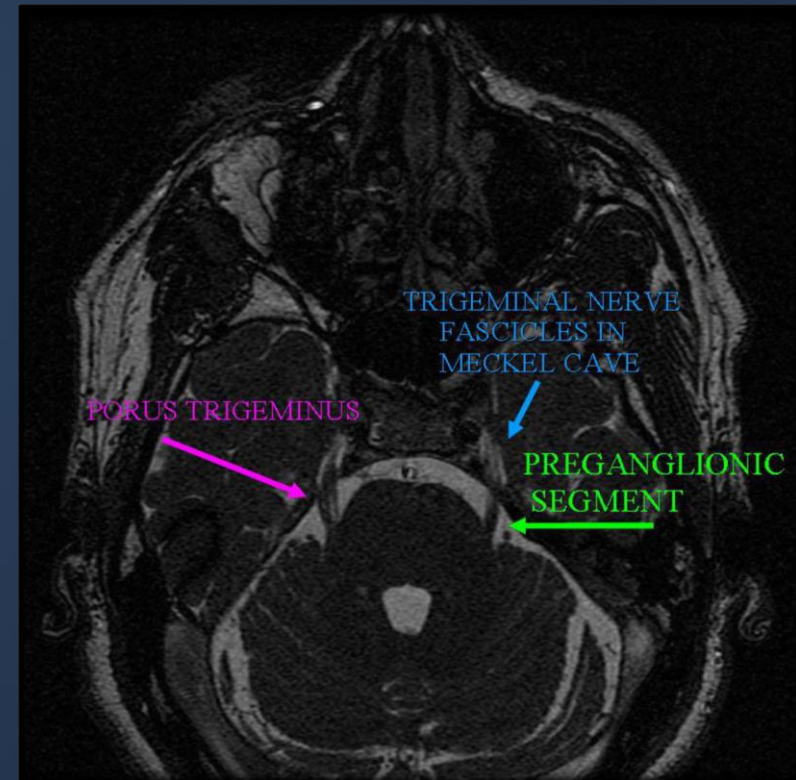
PREGANGLIONIC OR CISTERNAL SEGMENT

The nerves emerge from both sides of the pons and courses anterosuperiorly through the prepontine cistern. Afterwards, it enter the Meckel cave through the porus trigeminus.

INTERDURAL SEGMENT

The Meckel cave is formed by the meningeal layer of the dura lined with the arachnoid; it is filled with cerebrospinal fluid and continuous with the prepontine subarachnoid space.

The sensory root makes synapses with the trigeminal ganglion, also known as Gasserian or semilunar ganglion, which is located in the inferior aspect of the Meckel cave.



MRI Imaging Anatomy of Cranial Nerves..



(POSTGANGLIONIC) DIVISIONS

Ophthalmic nerve (V1)

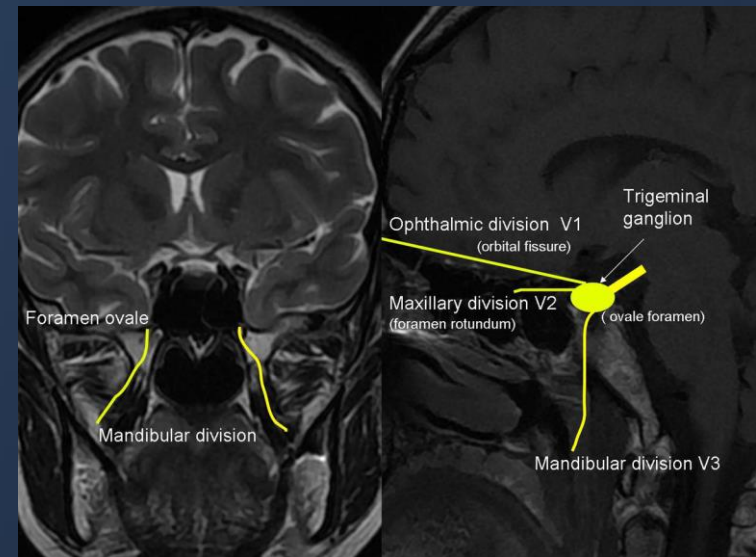
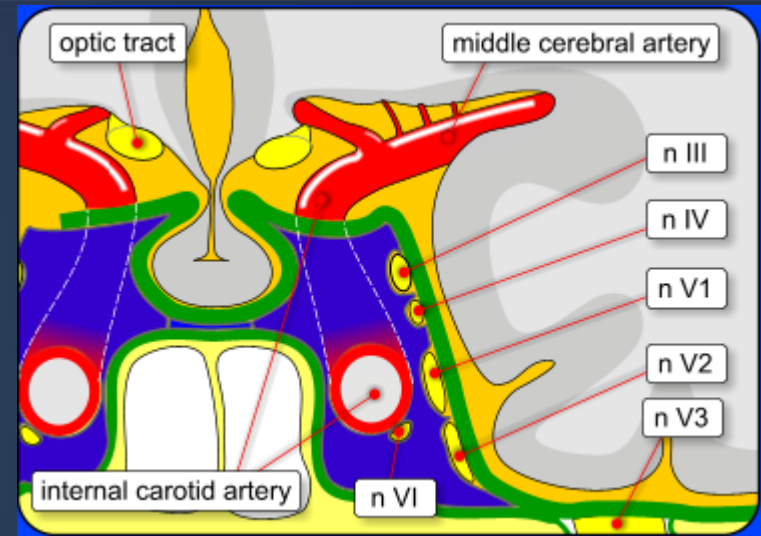
It courses in the lateral cavernous sinus wall, below the oculomotor and trochlear nerves. It exits the skull through superior orbital fissure and it divides into lacrimal, frontal and nasociliary nerves.

Maxillary nerve (V2)

Also it courses in the lateral cavernous sinus wall, below the ophthalmic nerve. Later on, it goes through the foramen rotundum and leads its way to the pterygopalatine fossa.

Mandibular nerve (V3)

It is formed by motor and sensory roots; the first one bypass the trigeminal ganglion. Both together exit directly from Meckel cave through foramen ovale into the masticator space, without passing through the cavernous sinus.



MRI Imaging Anatomy of Cranial Nerves..



VI CRANIAL NERVE = ABDUCENS NERVE

It is a motor nerve for the lateral rectus muscle, hence its name, that abduce the gaze.

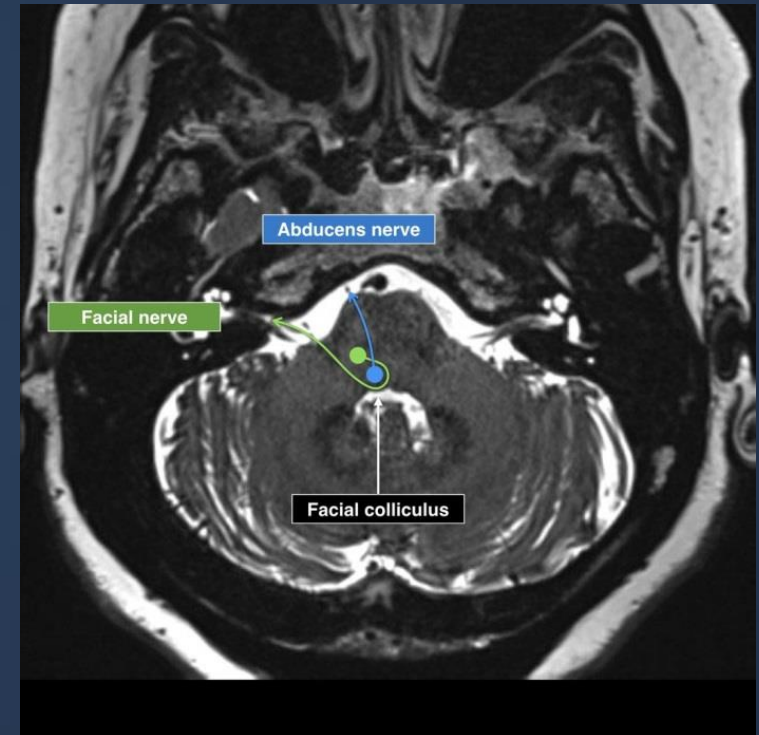
Five segments are noted as followed:

INTRAAXIAL SEGMENT

Paired abducens nuclei are located anterior to the fourth ventricle.

CISTERNAL SEGMENT

It emerges from the bulbopontine sulcus and travels anterosuperiorly within the prepontine cistern.



MRI Imaging Anatomy of Cranial Nerves..



INTERDURAL SEGMENT

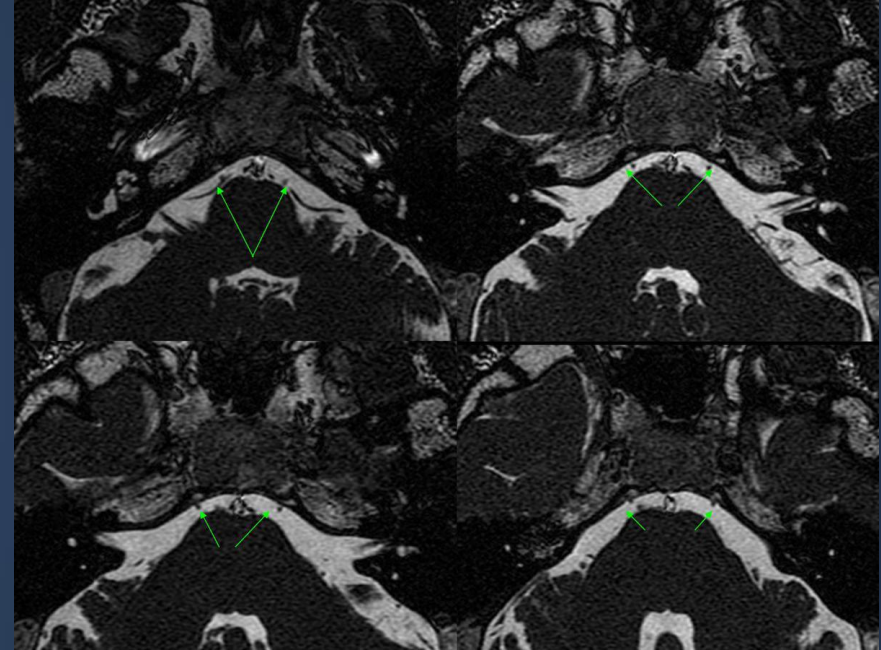
The abducens nerve penetrates the dura of the basisphenoid to enter the Dorello canal, and ascends to enter the cavernous sinus surrounded by arachnoid mater. Furthermore, it travels with the basilar venous plexus, also known as the petroclival venous confluence.

CAVERNOUS SEGMENT

The abducens nerve is the only nerve inside the cavernous sinus while the rest are located in the wall of the sinus.

EXTRACRANIAL SEGMENT

It enters the orbit through the superior orbital fissure together with the oculomotor and abducens nerves.



Four consecutive axial FIESTA images depict the origin of the sixth cranial nerve in the pons, its cisternal segment and its entering in the Dorello canal.

MRI Imaging Anatomy of Cranial Nerves..



VII CRANIAL NERVE = FACIAL NERVE

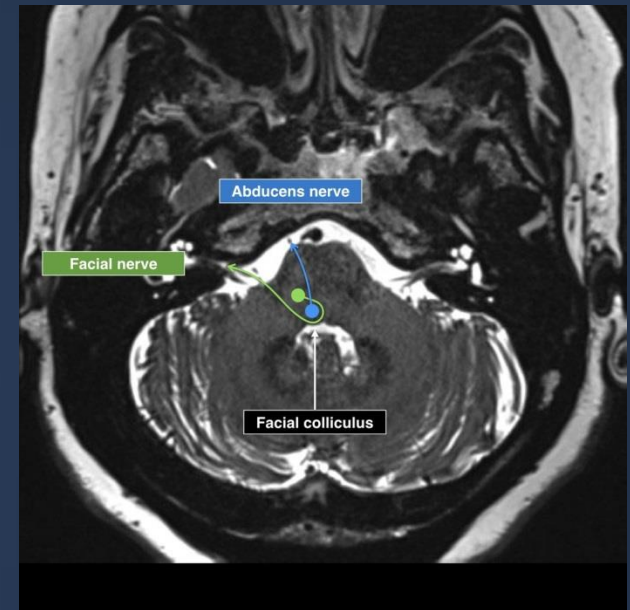
It is a mixed nerve: motor, parasympathetic and sensory (taste).

INTRAAXIAL SEGMENT

This nerve has three nuclei: one motor and two sensory.

CISTERNAL SEGMENT

It emerges from the lateral brainstem in the pontomedullary junction to enter cerebellopontine angle cistern.



MRI Imaging Anatomy of Cranial Nerves..



INTRATEMPORAL SEGMENT

The facial nerve in the temporal bone can be divided into four segments:

IAC segment:

it extends from the porus acusticus to the IAC fundus. The IAC is divided into quadrants by the falciform transverse crest and the Bill bar vertically. The facial nerve occupies the anterosuperior quadrant.

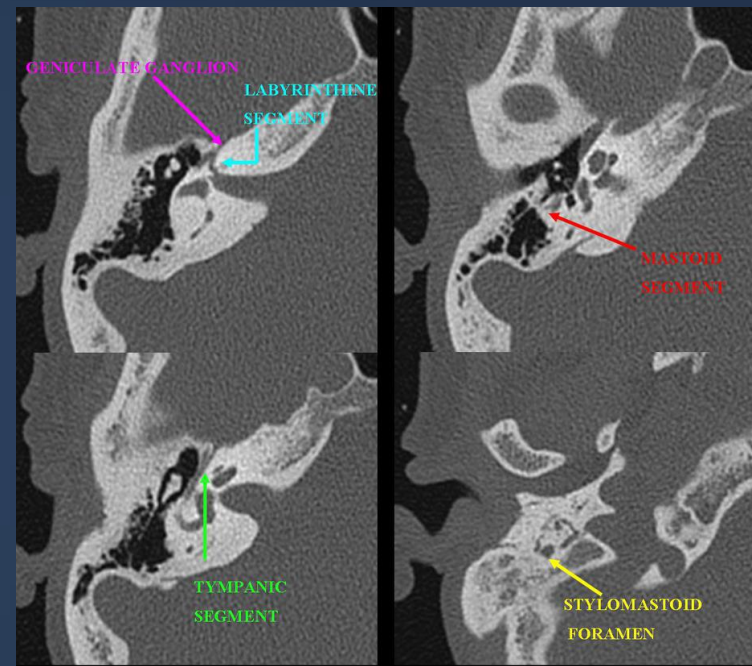
Labyrinthine segment:

connects fundal facial nerve to geniculate ganglion (anterior genu).

Tympanic segment:

between the anterior and posterior genu, passing under lateral semicircular canal.

Mastoid segment: it exits this segment through the stylomastoid foramen.



EXTRACRANIAL SEGMENT

Exiting the stylomastoid foramen, the nerves leads to the parotid, where passes lateral to the retromandibular vein. This nerve branches within the parotid.

MRI Imaging Anatomy of Cranial Nerves..



VIII CRANIAL NERVE= VESTIBULOCOCHLEAR NERVE

It is a sensory nerve of the balance (vestibular) and hearing (cochlear).

COCHLEAR NERVE

It arises from neurons located in the spiral ganglion within the modiolus of the cochlea. The peripheral fibers travel to the organ of Corti, in the cochlear duct within the cochlea, while the central fibers join to form the auditory component of the VIII cranial nerve.

VESTIBULAR NERVE

It arises from neurons located in the vestibular (Scarpa) ganglion located within the vestibular nerve in the fundal portion of the IAC, not visible on imaging. Peripheral fibers pass to sensory epithelium of utricle, saccule and semicircular canals. Central fibres join to form superior and inferior vestibular nerves.

The IAC is divided into four quadrants by the falciform crest (transverse crest) and the Bill bar (vertical bony structure), not visible on imaging.

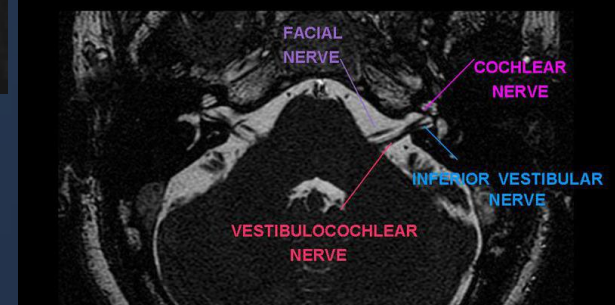
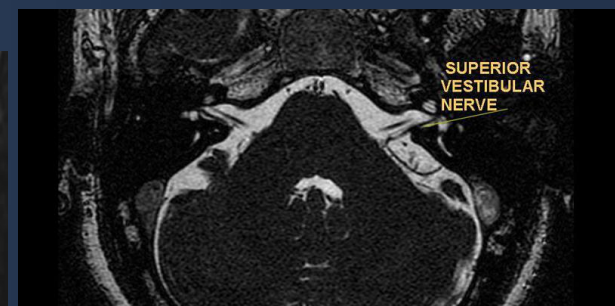
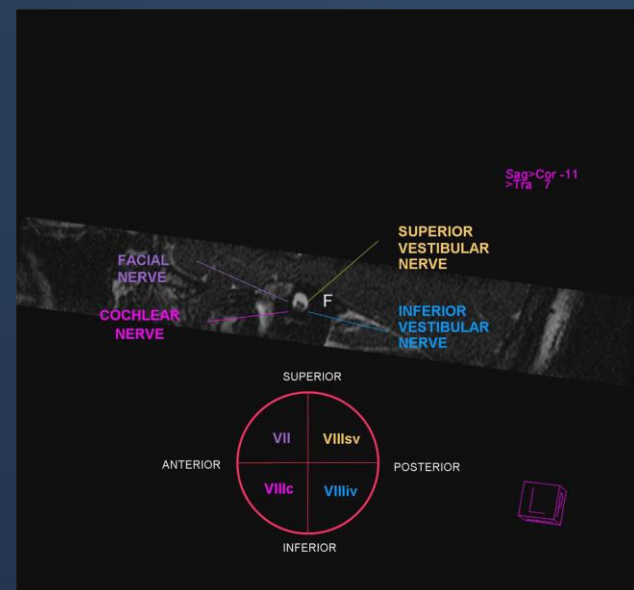
MRI Imaging Anatomy of Cranial Nerves..



The facial nerve is located in the antero-superior quadrant, the cochlear nerve in the anteroinferior quadrant while the VIII vestibular branches pass through the posterosuperior and posteroinferior quadrants respectively.

The cochlear and the superior and inferior vestibular nerves join altogether near the porus acusticus to form the vestibulocochlear nerve which travels within the cerebellopontine angle to enter the lateral brainstem at the junction of the pons and the medulla.

The vestibular nuclear complex is formed by four nuclei located in the lower pons, at the level of the fourth ventricle.



MRI Imaging Anatomy of Cranial Nerves..



IX CRANIAL NERVE=GLOSSOPHARYNGEAL NERVE

This cranial nerve is a mixed one, which carries the information of the taste to the posterior 1/3 of the tongue, sensation to middle ear and pharynx, parasympathetic fibers to the parotid gland, viscerosensory information to carotid body and sinus and motor fibers to stylopharyngeus muscle.

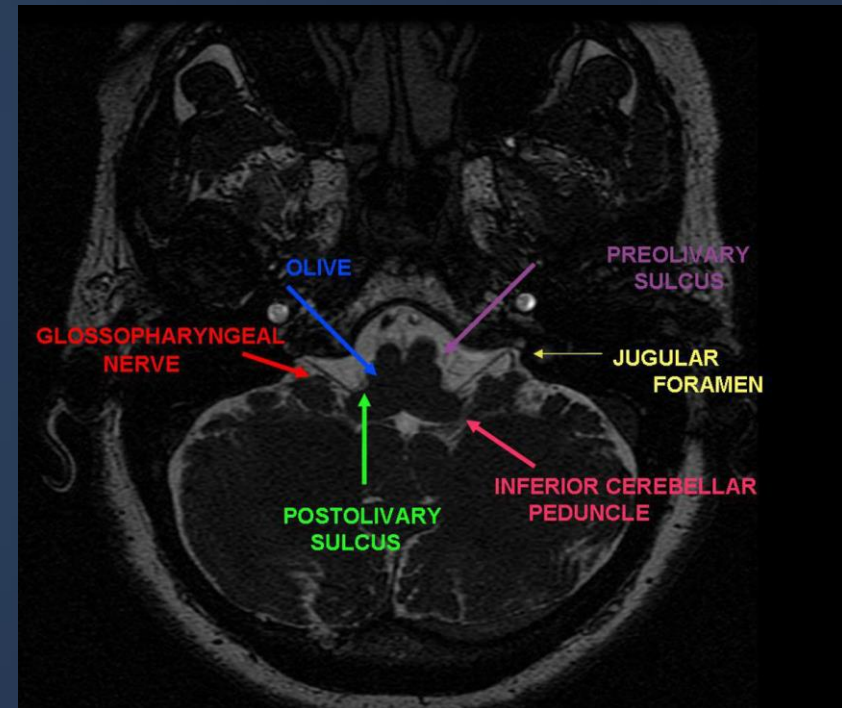
It can be divided into four segments:

INTRAAXIAL SEGMENT

Glossopharyngeal nuclei are in upper and middle medulla.

CISTERNAL SEGMENT

Exits lateral medulla in the postolivary sulcus, just above the vagus nerve. Later on, the glossopharyngeal nerve together with the vagus nerve and the bulbar portion of the accessory nerve course anterolaterally within the basal cistern.



MRI Imaging Anatomy of Cranial Nerves..

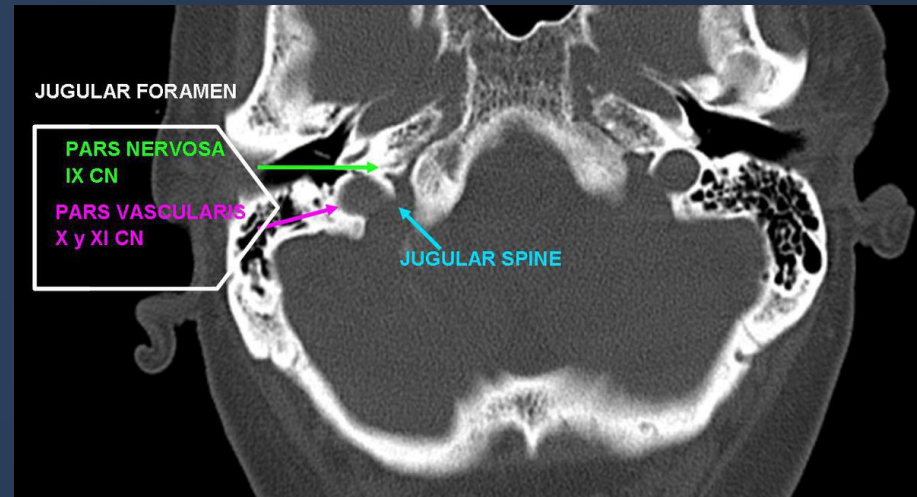


SKULL BASE SEGMENT

Passes through the pars nervosa portion of the jugular foramen. The vagus and accessory nerves are posterior within the pars vascularis portion of the jugular foramen.

EXTRACRANIAL SEGMENT

Exits skull base through jugular foramen into anterior nasopharyngeal carotid space, where it is lateral to internal carotid artery. Finally it ends in the posterior sublingual space in the floor of the mouth as it carries the taste to posterior 1/3 of the tongue.



MRI Imaging Anatomy of Cranial Nerves..



X CRANIAL NERVE= VAGUS NERVE

The vagus nerve has four components: parasympathetic, motor, visceral and sensory ones.

Four segments are noted:

INTRAAXIAL SEGMENT

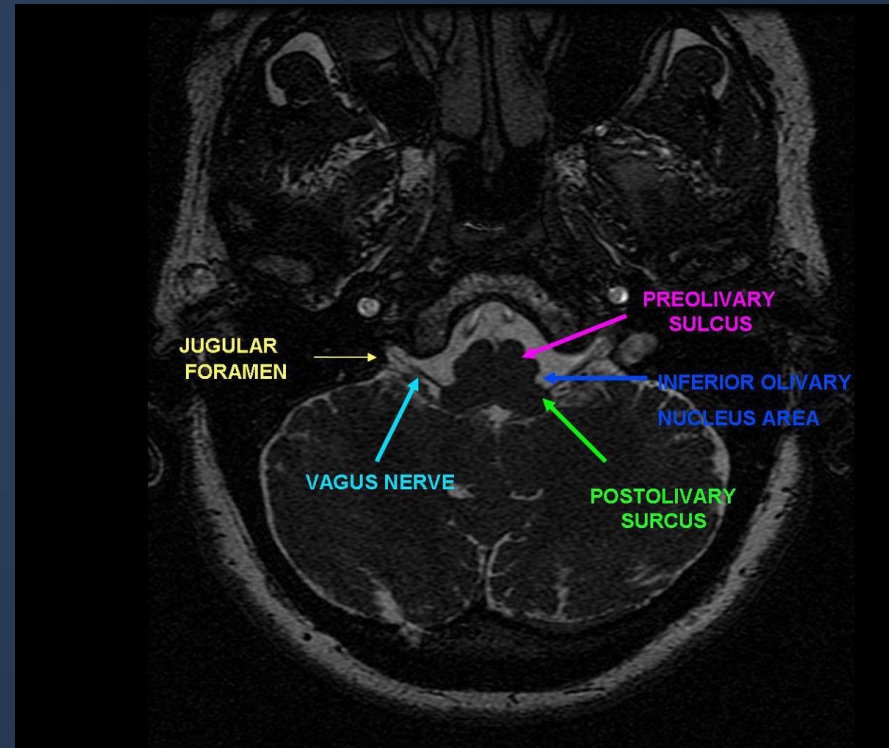
Vagal nuclei are in the upper and middle medulla.

CISTERNAL SEGMENT

It exits the lateral medulla through the postolivary sulcus, underneath the glossopharyngeal nerve and above the bulbar portion of the spinal nerve; altogether travel anterolaterally through the basal cistern.

SKULL BASE SEGMENT

The vagus nerve travels in the pars vascularis portion of jugular foramen.



MRI Imaging Anatomy of Cranial Nerves..



EXTRACRANIAL SEGMENT

It exits the jugular foramen into nasopharyngeal carotid space and descends along posterolateral aspect of the internal carotid artery into the thorax. It passes anterior to the aortic arch on the left and the subclavian artery on the right.

The recurrent laryngeal nerve, an important branch of the vagus nerve, turns around at the level of the cervicothoracic junction on the right, while on the left, it does at the level of the aortopulmonary window.

This is the reason why, when distal vagal neuropathy is present, such as in vocal cord paralysis, the CT scan should extend to the cervicothoracic junction on the right and to aortopulmonary window on the left.

MRI Imaging Anatomy of Cranial Nerves..



XI CRANIAL NERVE= ACCESSORY NERVE

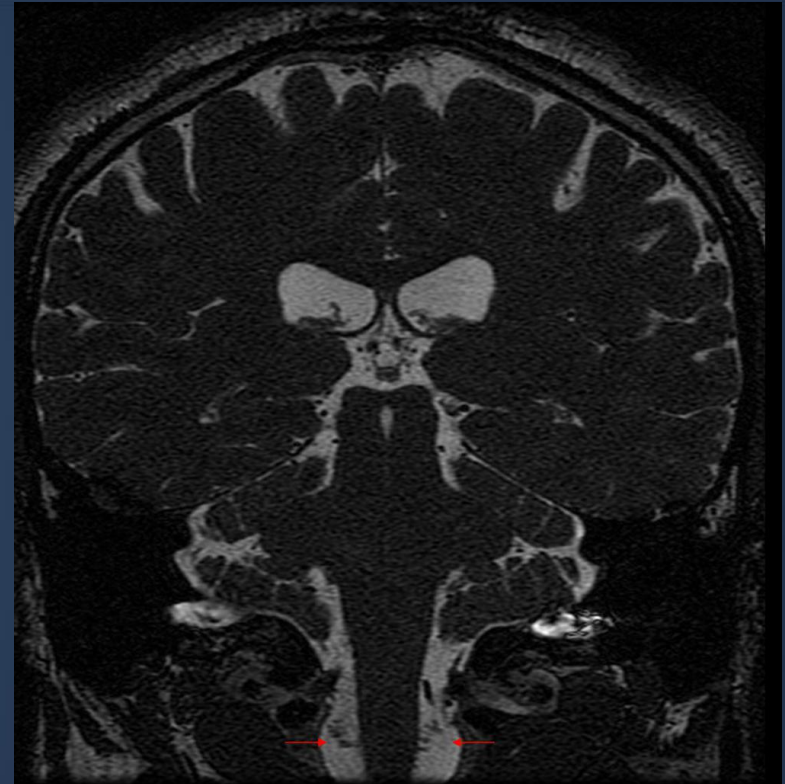
It is a motor cranial nerve supplying sternocleidomastoid and trapezius muscles.

Four segments are defined: intraaxial, cisternal, skull base and extracranial.

INTRAAXIAL SEGMENT

Two different nuclei, the ambiguus and spinal nuclei arise the bulbar and spinal fibers respectively.

The bulbar fibers exit the medulla inferiorly to vagus nerve while spinal fibers emerge from lateral aspect of cervical spinal cord, and then pass cranially through the foramen magnum.



Coronal FIESTA image shows multiple rootlets of the accessory nerve emerging from both sides of the lateral medulla (arrows).

MRI Imaging Anatomy of Cranial Nerves..



CISTERNAL SEGMENT

Bulbar portion courses anterolaterally through the basal cistern together with the ninth and tenth cranial nerves . Finally, bulbar and spinal portions join together within the lateral basal cistern.

SKULL BASE SEGMENT

The XI nerve are in the posterior aspect of the pars vascularis portion of the jugular foramen.

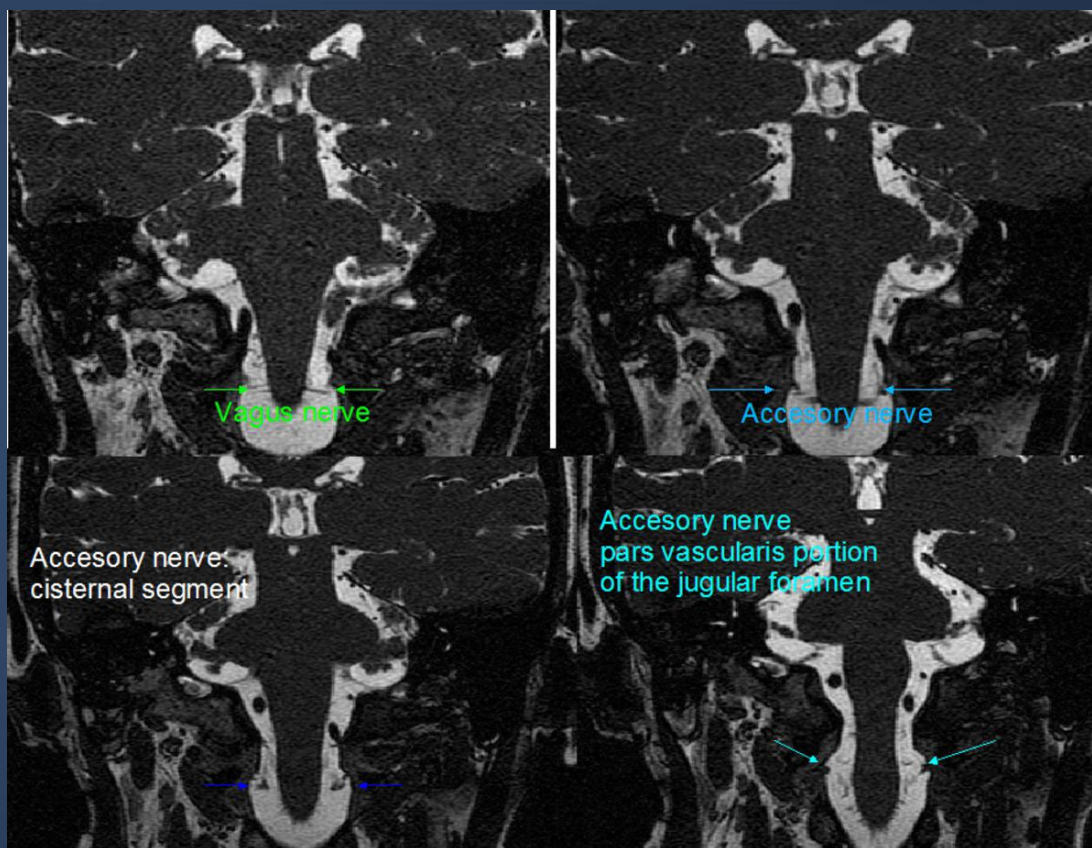
Also the jugular bulb, the vagus and the glossopharyngeal nerves travel in this foramen.

EXTRACRANIAL SEGMENT

The accessory nerve exits the jugular foramen into nasopharyngeal carotid space. The bulbar portion fibers transfer to vagus nerve and innervate the muscles of pharynx and larynx.

The spinal portion fibers supply the sternomastoid and trapezius muscles.

MRI Imaging Anatomy of Cranial Nerves..



Coronal FIESTA images. Bulbar portion of the eleventh cranial nerve courses anterolaterally through basal cistern together with ninth and tenth cranial nerves. Finally, bulbar and spinal portions join together within the lateral basal cistern

MRI Imaging Anatomy of Cranial Nerves..

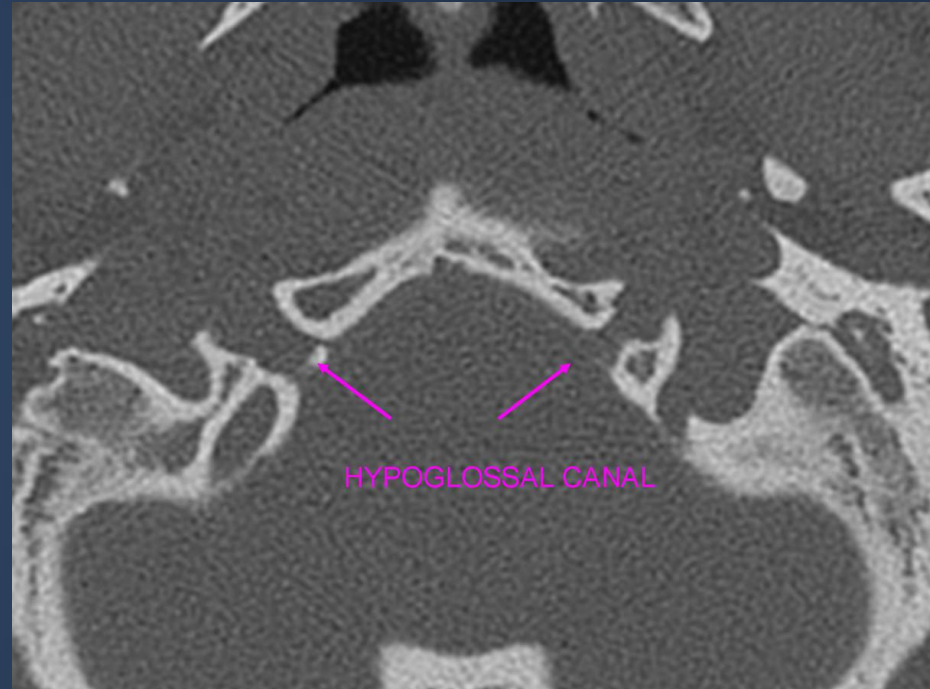


XII CRANIAL NERVE= HYPOGLOSSAL NERVE

It is a motor nerve to intrinsic and extrinsic muscles of the tongue, but for the palatoglossus muscle that is innervated by the vagus nerve.

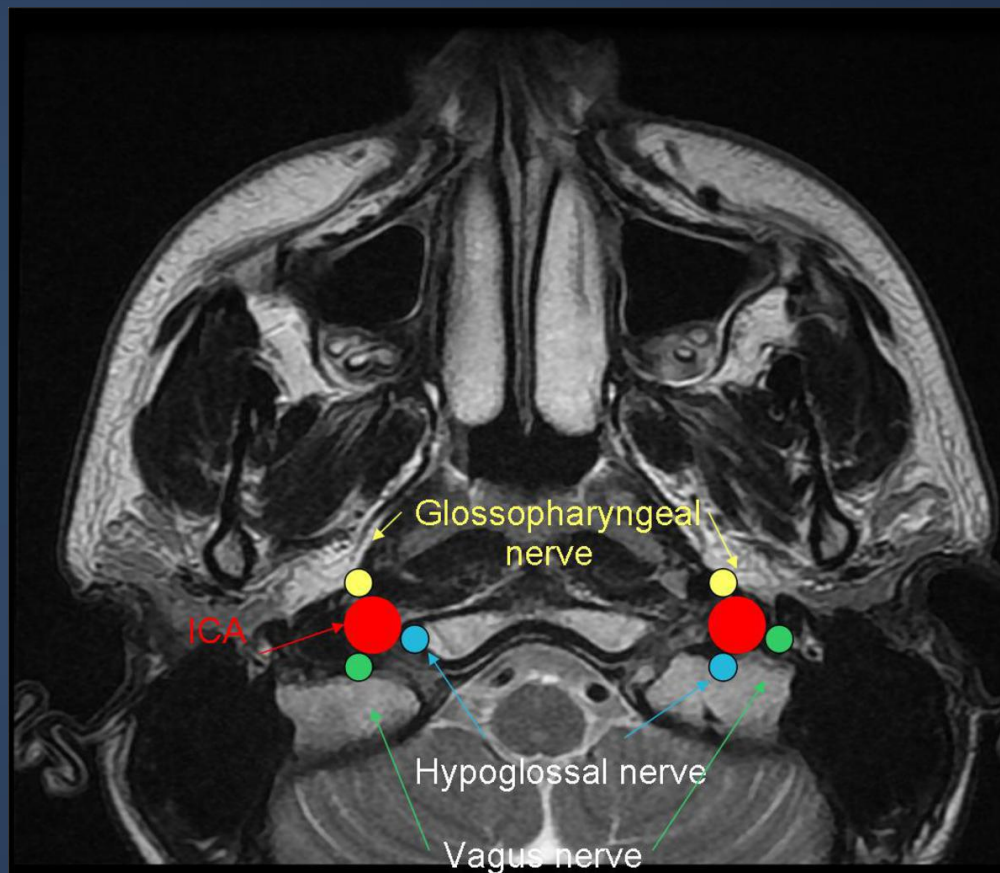
Multiple rootlets emerge from the ventrolateral sulcus, also known as pre-olivary sulcus; they are sometimes intermixed with the vagus rootlets. Hypoglossal rootlets within the medullary cistern lead their way into the hypoglossal canal, where they fuse into a single nerve root.

After leaving the skull base segment via the hypoglossal canal, the nerve in its extracranial segment travels in the posterior aspect of the carotid space; later on, it turns around at the inferior margin of the posterior belly of the digastric muscle.



Axial CT image depicts the hypoglossal canal. The hypoglossal nerve crosses this canal, abandoning so the skull base.

MRI Imaging Anatomy of Cranial Nerves..

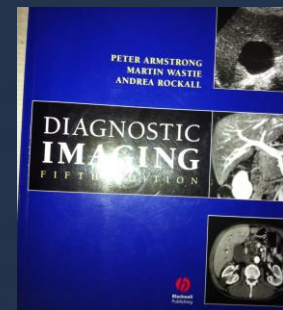
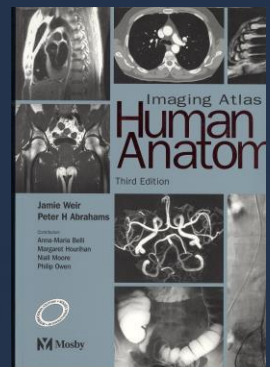
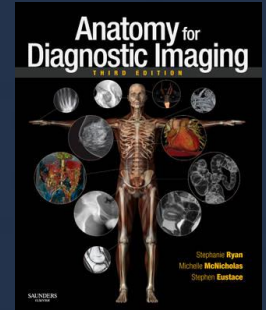


Axial T2-weighted MR image obtained at the level of nasopharynx depicts a schematic view of the IX, X and XII nerves in the carotid space.

Reference book and the relevant page numbers..



- Stephanie Ryan, “Anatomy for Diagnostic imaging”, 2nd Edition, Pages 61-66
- Jamie Weir, Peter Abraham, “Imaging Atlas of Human Anatomy” 3rd Edition, Pages 34-41
- Peter Armstrong, “diagnostic imaging”, 5th Edition, Pages (396-404)
- E. Pertusa santos et al, “ECR 2013”, Radiological anatomy of the cranial nerves (C-1663)



Thank You 😊

Dr. Hamdy Hassan
8-10/9/2019

