Aim

Introduction:

Pathology affecting the facial nerve is often clinically devastating as the facial nerve provides motor innervation to the muscle of facial expression. Imaging plays a crucial role in the diagnosis of facial nerve pathology. However, radiologic diagnosis of facial nerve pathology can be challenging due to meandering and complex anatomy of the facial nerve.

Methods and materials

Anatomy of the facial nerve:

The facial nerve has a motor nucleus and two sensory nuclei (superior salivatory nucleus and solitarius tract nucleus) which are located in the ventrolateral pontine tegmentum.\(^{(1)}\)

Motor fibers encircle the CN6 nucleus before emerges at the pontomedullary junction. The superior salivatory nucleus sends parasympathetic secretomotor fibers as nervus intermedius to the lacrimal, submandibular and sublingual glands. The solitary tract nucleus receives taste from the anterior two third of the tongue, with fibers travelling within the nervus intermedius.

Cisternal segment:

The motor nerve root joins the smaller sensory nervus intermedius, then emerges at the root exit zone in pontomedullary juction and travels anterolaterally in the cerebellopontine angle cistern.

Internal acoustic canal (IAC) segment:

From the porus accousticus, the facial nerve travels to the fundus of the IAC, in the anterior superior quadrant, above crista falciformis and anteriorly to Bill's bar.

Labyrinthine segment:
This segment of the facial nerve travels anterolaterally from the IAC fundus to the geniculate ganglion (anterior genu). The greater superficial petrosal nerve arises from the geniculate ganglion, carrying parasympathetic fibers to the lacrimal gland.

Tympanic segment:

From the geniculate ganglion, the tympanic segment travels to the posterior genu, immediately beneath the lateral semicircular canal.

Mastoid segment:

Just distal to the pyramidal eminence (posterior genu), the nerve passes vertically downwards to the stylomastoid foramen. It has several branches including:

1. Stapedius nerve supplies motor function to stapedius muscle.
2. Chorda tympani carries secretomotor fibers to the submandibular and sublingual glands and taste fibers from anterior two thirds of tongue.

Extratemporal segment:

After exiting the stylomastoid foramen, this segment of the facial nerve gives off a sensory branch that supplies part of the external acoustic meatus and tympanic membrane. It then enters the parotid gland between the deep and superficial lobes, lateral to the retromandibular vein. This segment of the facial nerve gives off five terminal motor branches: temporal, zygomatic, buccal, mandibular and cervical.

Normal enhancement of the facial nerve:

The normal facial nerve can demonstrate enhancement along at least one segment in 76% of cases, excluding the distal intrameatal and the labyrinthine segments.\(^{(2)}\) The geniculate ganglion, greater superficial petrosal nerve and the proximal tympanic segment generally demonstrate faint enhancement.\(^{(3)}\) The cisternal, meatal, labyrinthine, and extracranial segments of the facial nerve do not normally enhance. Enhancement of these segments should raise the possibility of pathological involvement. Asymmetrical enhancement or irregular thickening of the geniculate ganglion, tympanic and mastoid segments should also be considered pathological.
Fig. 1: Facial nerve anatomy: Axial MRI images. a: IAC segment. b: labyrinthine segment. c: geniculate ganglion. d: tympanic segment. e: mastoid segment.

References: Alfred Health - SOUTH YARRA/AU

Fig. 2: Facial nerve anatomy: Coronal CT images. a: IAC segment. b: "snake eyes" appearance as the tympanic segment doubles back next to the labyrinthine segment adjacent to the cochlea. c,d: labyrinthine and tympanic segments converge at the geniculate ganglion. e: mastoid segment below the lateral semicircular canal. e: mastoid segment in the stylomastoid canal.

References: Alfred Health - SOUTH YARRA/AU

Results

Common pathology affecting the facial nerve can be categorised as follow:
• Neoplasm
• Infection
• Inflammation/Idiopathic
• Vascular
• Trauma
• Congenital

**Neoplasm**

Neoplastic process involving the facial nerve is rare. Several neoplastic processes which commonly involve the facial nerve include facial nerve schwannoma, hemangioma, perineurial tumour spread from primary SCC or parotid gland malignancy, lipoma, glomus tumour and lipoma.

**Facial nerve schwannoma**

Facial nerve schwannoma is a rare benign tumour of Schwann cells that can affect anywhere along the facial nerve from its origin to its extracranial ramifications in the parotid space of the extracranial head and neck. It often affects multiple segments of the facial nerve with a predilection for the region around the geniculate ganglion. Patients may present with gradual facial nerve paralysis over many years or sensorineural hearing loss due to local mass effect from the tumour. (4)

**Imaging features:**

Enhancing mass in the cerebellopontine angle/internal acoustic canal extending and expanding into the labyrinthine canal ("labyrinthine tail") and geniculate ganglion ("ice-cream on cone" appearance). It is commonly iso to hypointense signal on T1 sequence and high signal on T2 sequence. They frequently enhance homogeneously, if small, and heterogeneously, if large. Large lesions may also demonstrate intramural cystic degeneration.
Fig. 3: Facial nerve schwannoma: Axial T1 post contrast images demonstrated an enhancing mass in the internal acoustic canal extending into the labyrinthine canal with an enlarged geniculate ganglion (ice-cream on cone appearance).

References: Alfred Health - SOUTH YARRA/AU

Facial nerve haemangioma

Facial nerve haemangioma is a rare vascular malformation, often arising from region around the geniculate ganglion. Patients with hemangiomas that originate in the geniculate fossa most often present with facial nerve paralysis that is slowly progressive over the course of several weeks. (5) Sensorineural hearing loss and pulsatile tinnitus may occur if there is erosion of the cochlear otic capsule. (6)

Imaging features: Enhancing mass centred at the geniculate ganglion, with permeative or honeycomb bone matrix on CT. Tumour size ranges from 2mm to 2cm. The lesion may spread along the greater superficial petrosal nerve anteromedially if large.
Perineural tumour spread

Several malignant tumours of the parotid gland can spread along the facial nerve. These tumours include adenoid cystic carcinoma, mucoepidermoid carcinoma, adenocarcinoma, malignant mixed tumors, acinic cell carcinoma, lymphoma, squamous cell carcinoma and melanoma metastases.\(^7\) Adenoid cystic carcinoma has the highest tendency to cause perineural tumour spread (70 -75\%)\(^8\) and it is the most common malignancy to cause perineural spread along the facial nerve.

Imaging features: Irregular, tubular enhancement along extracranial and intratemporal segment of the facial nerve , extending from an enhancing intraparotid mass. The perineural tumour spread may be contiguous or skipped and it can extend proximally up to the cisternal segment.

**Fig. 4:** Facial haemangioma: Enhancing mass centred at the geniculate ganglion on contrast enhanced MRI, with permeative bone matrix on CT.

**References:** Alfred Health - SOUTH YARRA/AU
Fig. 5: Perineural tumour spread: Enhancing primary skin SCC with parotid nodal metastasis and thickened, nodular perineural tumour spread along the extracranial and mastoid segment of the facial nerve.

References: Alfred Health - SOUTH YARRA/AU

Glomus tumour

Glomus tumour, also known as paraganglioma, is a rare benign vascular tumour that arises from the paraganglia cells. Depending on its location, glomus tumours of the head and neck can be divided into glomus tympanicum, jugulare, vagale and carotid body tumour. Facial nerve paralysis is a rare symptom/complication of glomus tympanicum (5%). More common presentations are pulsatile tinnitus and conductive hearing loss.

Imaging features: Glomus tympanicum appears as an enhancing mass on the cochlear promontory with "salt and pepper" appearance on MRI. Salt and pepper appearance refers to punctate hyperintensity (salt) and flow voids (pepper) on T1 weighted images. Small lesions may be difficult to see on CT, but large lesions cause permeative destructive bone changes, with erosion of the middle ear cavity and ossicles. Glomus jugulotympanicum may extend from the cochlear promontory to the jugular foramen, with the same imaging appearances described above.
Fig. 6: Glomus jugulotympanicum : Enhancing tumour with "salt and pepper" appearance, centred in the jugular foramen with permeative destructive bone changes on CT. The tumour extends laterally involving the mastoid segment and superiorly involving the IAC segment of the facial nerve.

References: Alfred Health - SOUTH YARRA/AU

Infection

Acute or chronic infection of the middle ear and mastoid can spread to the facial nerve due to its course within the temporal bone. Cholesteatoma affecting the middle ear also has the potential to erode into the intratemporal segment of the facial nerve.

Otomastoiditis

Acute or chronic otomastoiditis is an infection affecting the middle ear and mastoid air cells, usually affecting young children and most commonly due to bacterial infection. Complications of otomastoiditis are rare, as the disease is usually responsive to prompt antibiotic treatment. However, complications of otomastoiditis may occur due to antibiotic resistance, or in immunocompromised patients. The complications include coalescent mastoiditis, petrous apicitis, labyrinthitis, facial nerve paralysis and hearing loss.
Imaging features: Middle ear and mastoid opacification on CT. In coalescent mastoiditis, there is erosion of the mastoid septation and cortex. On MRI, there is T1 isointense and T2 hyperintense inflammatory debris, with diffuse enhancement within the middle ear and mastoid. The facial nerve is most commonly affected in its tympanic and upper mastoid segments. In cases of acute otomastoiditis, the lesion is often not destructive and reversible. (9)

**Fig. 7**: Acute otomastoiditis: Enhancing tissue in the middle ear and mastoid air cells. There is also enhancement of the mastoid segment of the facial nerve which lies in the region of the inflammatory phlegmon, in keeping with facial nerve involvement. Soft tissue opacitication in the middle ear and mastoid air cells on CT. No erosion of the mastoid septation and cortex to indicate coalescent mastoiditis.


**References:** Alfred Health - SOUTH YARRA/AU

**Inflammation/idiopathic**

Several inflammatory/idiopathic conditions are known to affect the facial nerve. These conditions are Bell's palsy, Guillain-Barré Syndrome, sarcoidosis, multiple sclerosis and wegener's granulomatosis.

**Guillain-Barré Syndrome**

Guillain-Barré Syndrome is an acute inflammatory demyelinating polyradiculopathy of uncertain aetiology. Miller Fisher Syndrome is a variant of Guillain- Barré Syndrome which involves the cranial nerves. Patients may present with the clinical triad of ophthalmoplegia, ataxia and areflexia. In most cases, multiple cranial nerves are involved, and the facial nerve can be involved up to 27 - 50% and often bilaterally.\(^{(10)}\) There is usually a history of preceding respiratory or gastrointestinal viral illness.

Imaging features:

Bilateral enhancement of the infratemporal facial nerve, often involving the IAC fundus, labyrinthine segment, geniculate ganglion, tympanic and mastoid segments.
Fig. 8: Guillain-Barré Syndrome: Bilateral enhancement of the IAC fundus, labyrinthine segment, geniculate ganglion, tympanic and mastoid segments of the facial nerves.

References: Alfred Health - SOUTH YARRA/AU

Bell's palsy

Bell's palsy is a rapidly progressive facial nerve paralysis. It is thought to be due to reactivation of latent herpes simplex virus in the geniculate ganglion.

Imaging features: Vivid asymmetrical enhancement of the facial nerve, commonly on either side of the geniculate ganglion - in the fundal and labyrinthine segments. The infratemporal segment may also be affected.
Fig. 9: Bell’s palsy: Vivid asymmetrical enhancement of the left IAC fundus, labyrinthine, geniculate ganglion, tympanic and mastoid segments of the facial nerve.

References: Alfred Health - SOUTH YARRA/AU

Neurovascular compression

The facial nerve may be compressed by a vascular loop, usually at its root exit zone in the cerebellopontine angle cistern, causing hemifacial spasm. The vascular loop may be the anterior inferior cerebellar artery (most common), posterior inferior cerebellar artery or vertebral artery.

Less commonly, the facial nerve may be compressed within the internal acoustic canal by a vascular loop.\(^{(11)}\)

Imaging features: High resolution T2 weighted sequence (FIESTA) demonstrating a serpigenous vascular loop contacting and displacing the facial nerve, most commonly at its root exit zone, but could also be in the internal acoustic canal.
Fig. 10: Neurovascular compression: Long slender right AICA (red arrow) contacting and displacing the facial nerve (yellow arrow) in the internal acoustic canal causing hemifacial spasm. A piece of surgical Teflon (blue arrow) has been inserted in between the AICA and the right facial nerve with good post operative outcome.

References: Alfred Health - SOUTH YARRA/AU

Trauma

Temporal bone fracture

Temporal bone fracture occurs with severe blunt trauma to the skull. Temporal bone fracture is traditionally described as longitudinal, transverse or mixed type according to radiographic anatomical involvement. However, there is a newer system which classifies the temporal bone fracture according to otic capsule violating or sparing in order to predict clinical sequelae of trauma.

Whilst longitudinal fractures (75-80%) are more common than transverse fractures, facial nerve injury is reported to occur in only 25% of longitudinal and 40% to 50% of transverse fractures. (12)

Fractures that do not violate the otic capsule are much less likely to damage the cochleovestibular system or the facial nerve, owing to the protective density of the otic capsule bone. In Dahiya and colleagues’ (13) study of 55 temporal bone fractures, patients with otic capsule-violating fractures were more than twice as likely to have facial nerve injury, 4 times as likely to have CSF leakage, and 7 times as likely to have SNHL than those with otic capsule-sparing fractures.

Imaging features: Longitudinal fracture typically runs parallel to the petrous pyramid through the middle ear. Transverse fractures run perpendicular to the petrous ridge, from the foramen magnum across the petrous pyramid. Transverse fractures often affect the labyrinthine segment, while longitudinal fractures more often affect the geniculate ganglion, tympanic and mastoid segment.
Fig. 11: Temporal bone Trauma: Longitudinal temporal bone fracture extending through the geniculate ganglion and tympanic segment of the facial nerve causing facial nerve palsy.

References: Alfred Health - SOUTH YARRA/AU

Congenital malformations:

There are multiple congenital anomalies affecting the facial nerve, including facial nerve canal dehiscences, facial nerve aplasia/hypoplasia, duplicated IAC, and many congenital syndromes such as Möbius, DiGeorge, Goldenhar, CHARGE, trisomy 13, and trisomy 18.
Fig. 12: Möbius syndrome: Hypoplastic right facial nerve (yellow arrow) and absent left facial nerve (blue arrow) in a child with bilateral facial and abducens nerves palsy.

References: Dr Yune Kwong, Radiopaedia

Conclusion
Understanding of the anatomy and pathology of the facial nerve will improve one's ability to diagnose. This article reviews the radiologic findings of several common pathologies that affect the facial nerve.

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