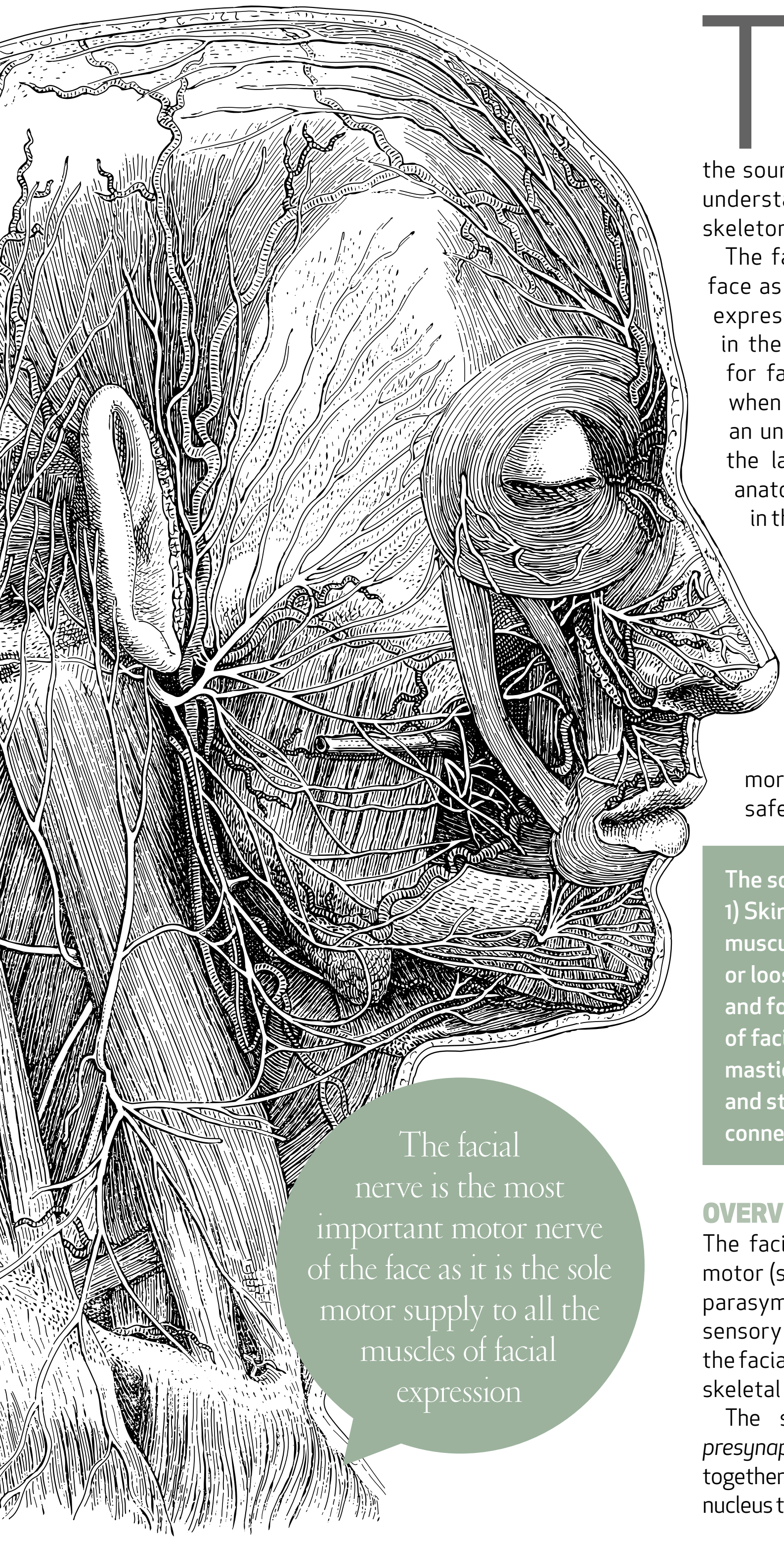
Nerve tracking

Dr Sotirios Foutsizoglou on the anatomy of the facial nerve



> The facial nerve is the most important motor nerve of the face as it is the sole motor supply to all the muscles of facial expression

The anatomy of the human face has received enormous attention during the last few years, as a plethora of anti-ageing procedures, both surgical and non-surgical, are being performed with increasing frequency. The success of each of those procedures is greatly dependent on the sound knowledge of the underlying facial anatomy and the understanding of the age-related changes occurring in the facial skeleton, ligaments, muscles, facial fat compartments, and skin.

The facial nerve is the most important motor nerve of the face as it is the sole motor supply to all the muscles of facial expression and other muscles derived from the mesenchyme in the embryonic second pharyngeal arch.[1] The danger zone for facial nerve injury has been well described. Confidence when approaching the nerve and its branches comes from an understanding of its three dimensional course relative to the layered facial soft tissue and being aware of surface anatomy landmarks and measurements as will be discussed in this article.

Aesthetic medicine is not static, it is ever evolving and new exciting knowledge emerges every day unmasking the relationship of the ageing process and the macroscopic and microscopic (intrinsic) age-related changes. Sound anatomical knowledge, taking into consideration the natural balance between the different facial structures and facial layers, is fundamental to understanding these changes which will subsequently help us develop more effective, natural, long-standing and most importantly, safer rejuvenating treatments and procedures.

The soft tissue of the face is arranged in five layers: 1) Skin; 2) Subcutaneous fat layer; 3) Superficial musculoaponeurotic system (SMAS); 4) Areolar tissue or loose connective tissue (most clearly seen in the scalp and forehead); 5) Deep fascia formed by the periosteum of facial bones and the fascial covering of the muscles of mastication (lateral face). All five layers are interconnected and stabilised by a network of fibrous condensations of connective tissue, the retaining ligaments.

OVERVIEW OF THE FACIAL NERVE

The facial nerve (Cranial Nerve VII) conveys a combination of motor (special visceral efferent), sensory (visceral afferent), and parasympathetic fibres. Each of the different fibre types (different sensory modalities) is associated with a particular nucleus.[2] From the facial nucleus, the *special visceral efferent* axons innervate the skeletal muscles of facial expression (motor root).

The superior salivatory nucleus contains *visceral efferent presynaptic parasympathetic* neurons whose axons are grouped together with the *visceral afferent (gustatory)* fibres from the solitary nucleus to form the nervus intermedius (intermediate nerve).

A *nucleus* is a cluster of nerve cell bodies in the central nervous system, located deep within the cerebral hemispheres and brainstem. The neurons in one nucleus usually have roughly similar connections and functions. Nuclei are connected to other nuclei by tracts, the bundles (fascicles) of axons (nerve fibres) extending from the cell bodies. A nucleus is one of the two most common forms of nerve cell organisation, the other being layered structures such as the cerebral cortex or cerebellar cortex.[3]

The *solitary nucleus* is a series of purely sensory nuclei forming a vertical column of grey matter embedded in the medulla oblongata. From the solitary nucleus runs the solitary tract which includes fibres from the facial, glossopharyngeal and vagus nerves and projects to, among other regions, the reticular formation, parasympathetic preganglionic neurons, hypothalamus and thalamus, forming circuits that contribute to autonomic regulation.[4]

Nerve fibres from the intermediate nerve aggregate with the special visceral efferent axons from the facial (motor) nucleus to form the facial nerve. The facial nerve emerges in the cerebellopontine angle between the pons and olive and follows a circuitous intracranial and extracranial course before dividing into its main five motor branches that innervate the muscles of facial expression.

Most muscles of facial expression can be classified as either constrictors or expanders of the ocular, nasal, or oral sphincters.

The course of the facial nerve

Anatomically, the course of the facial nerve can be divided into two parts:

- **Intracranial** – the course of the nerve through the cranial cavity and the cranium itself.
- **Extracranial** – the course of the nerve outside the cranium, through the face and neck.

The nervus intermedius along with the visceromotor axons from the facial motor nucleus form the facial nerve that emerges at the lower border of the pons (part of the brainstem). The facial nerve exits the cranial cavity through the internal acoustic meatus, a 1cm long opening in the petrous part of the temporal bone. Here the facial nerve is accompanied by the vestibulocochlear nerve (CN VIII) and lies in very close proximity to the inner ear.[5] Still within the temporal bone, the nerve leaves the internal acoustic meatus, and enters into the facial canal.[6] The facial canal (*canalis nervi facialis*) is a Z-shaped structure running through the temporal bone from the internal acoustic meatus to the stylomastoid foramen. In humans it is approximately 3cm long, which makes it the longest human osseous canal of a nerve.[16] Within the facial canal the facial nerve forms the external genu which marks the location of the geniculate ganglion. Between the geniculate ganglion and its exit from the cranium via the stylomastoid foramen at the base of the skull, the facial nerve gives off three branches (Table 1):

- The parasympathetic greater petrosal nerve which arises directly at the geniculate ganglion;
- The stapedial nerve (motor fibres to stapedius muscle)
- The chorda tympani that contains gustatory fibres (special sensory fibres to the anterior 2/3 tongue) as well as presynaptic parasympathetic fibres. The chorda tympani passes through the tympanic cavity and petrotympanic fissure and joins the lingual nerve.[5]

Function	Branch	Notes
Motor	Stapedius	Causes hyperacusis if damaged
	Posterior belly of digastric	Elevates hyoid as part of swallowing mechanism
	Stylohyoid	Elevates hyoid
	Posterior auricularis	Moves earlobe
	Five divisions within parotid gland	• **Temporal:** innervates frontalis and orbicularis oculi • **Zygomatic:** innervates orbicularis oculi, levator labii superioris and zygomaticus muscles • **Buccal:** innervates buccinators, levator anguli oris and nasalis muscles • **Marginal mandibular:** innervates depressor anguli oris, depressor labii inferioris and mentalis • **Cervical:** innervates platysma
Secretomotor	Greater superficial petrosal nerve	Innervates lacrimal, nasal and palatine glands
	Chorda tympani	Innervates submandibular and sublingual salivary glands
Taste	Chorda tympani	Taste to the anterior 2/3 of the tongue
Other sensory	Multiple communications	Communications with trigeminal, glossopharyngeal, vagus, greater auricular and auriculotemporal nerves explain associated mastoid, ear, head and neck pain in herpes zoster and Bell's Palsy

Table 1. Intracranial and extracranial branches of the facial nerve.

The first extracranial branch to arise immediately after the emergence of the facial nerve from the stylomastoid foramen is the *posterior auricular nerve* which supplies motor fibres to the auricularis posterior and the occipitalis (posterior belly of the occipitofrontalis). The *posterior auricular nerve* also conveys somatosensory fibres from the external ear. Distal to this, motor branches are sent to the posterior belly of the digastric muscle and to the stylohyoid muscle. >

Table 2. Nerves of the petrous bone[2]

Greater petrosal nerve	Presynaptic parasympathetic branch from CN VII to the pterygopalatine ganglion (lacrimal gland, nasal glands)
Lesser petrosal nerve	Presynaptic parasympathetic branch from CN IX to the otic ganglion (parotid gland, buccal and labial glands)
Deep petrosal nerve	Postsynaptic sympathetic branch from the internal carotid plexus; unites with the greater petrosal nerve to form the nerve of the pterygoid canal.

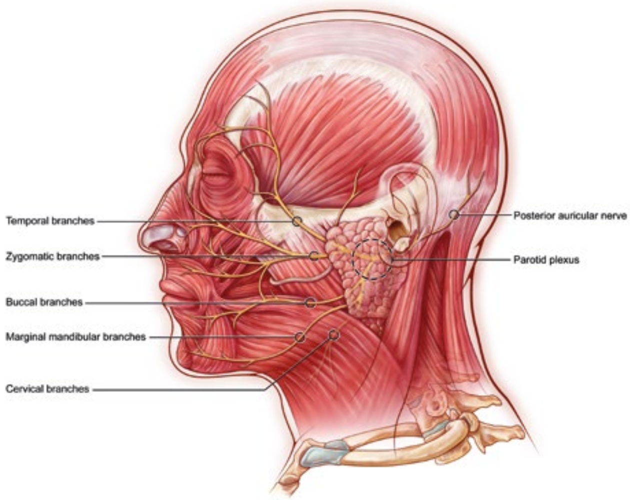


Figure 1: The terminal branches of the facial nerve
Credit: Facial Nerve, illustration: Evan Oto/Science Photo Library
An illustration of the facial nerve, the seventh cranial nerve, as well as the muscles of the face. The facial nerve is responsible for motor control of all the muscles of facial expression, as well as relays sensory information such as touch and taste. The facial nerve also branches off into the temporal, zygomatic, buccal, marginal mandibular, and cervical branches.

Digastric muscles, each of which has two bellies that descend towards the hyoid bone, are joined by an intermediate tendon. The anterior and posterior bellies of the digastrics muscle form the boundaries of the "digatric triangle" or the submandibular triangle in the anterior neck. The anterior belly of digastric is supplied by the mylohoid nerve, a branch of the inferior alveolar nerve, whereas the posterior belly is motor innervated by a branch of the facial nerve. The difference in nerve supply between the two bellies results from the embryological origin of the anterior and posterior bellies from the 1st and 2nd pharyngeal arches respectively. CN V is the nerve to the 1st arc, and CN VII supplies the 2nd.[1]

Superficial placement of filler or insertion of suspension threads above the zygomatic arch or in the temporal region can injure the temporal nerve. For instance, when I volumise temporal hollowness I always deposit volumising agents over the periosteum (deep injections) thus avoiding the rami of the temporal branch and temporal vessels. For eyebrow lifting using a filler in a retrograde linear fashion following the lateral third of the natural eyebrow over the periosteum (deep injection) is also safe (refer to the surface landmarks as described).

The main trunk of the facial nerve, now, runs anteroinferiorly into the parotid gland where it forms the parotid plexus from which five anteriorly radiating branches (*temporal, zygomatic, buccal, marginal mandibular,* and *cervical*) are distributed to the muscles of facial expression across the face (Fig. 1). Please note that although intimately related to the parotid gland (and often contacting the submandibular gland via one or more its lower branches), the main trunk of the facial nerve (motor root) does not deliver nerve fibres to the salivary glands.

TERMINAL BRANCHES OF THE FACIAL NERVE

The terminal branches exit the parotid gland and remain deep to the layer five in the lateral face. As they approach the anterior face, the branches traverse layer four to reach the underside of the mimetic muscles of the face.[7] It is at these transition points across layer four that the nerves are at greatest risk of injury.[8,9] The transitions occur at predictable locations, in close association with retaining ligaments that provide stability and protection for the nerves.

The surface marking of the *temporal* branch of the facial nerve is along the Pitanguy line, from a point 0.5 cm below the tragus to a point 1.5 cm lateral to the supraorbital rim where it enters the frontalis just below the anterior branch of the superficial temporal artery.[10] Inferior to the zygomatic arch the nerve runs between layers four and five whereas above the zygomatic arch it transitions to a more superficial location in an envelope of superficial temporal fascia along with the intermediate fat pad.[11]

There are up to three or four *zygomatic* branches exiting the parotid gland deep to the deep fascia just below the zygoma and cephalad to the parotid duct.[12] The upper branch passes above the orbital rim to supply the frontalis and the upper portion of the orbicularis oculi. The lower branches supply the lower orbicularis oculi entering the muscle at its inferolateral corner, and then innervate the zygomaticus major and minor muscles from the underside in close association with the zygomatic ligaments.[13] The zygomatic nerve also supplies the depressor supercilii at the medial orbital rim.

The *buccal* branch is tightly bound to the anterior surface of masseter within the paratidomasseteric fascia. It is usually divided into the upper buccal trunk which runs parallel to the parotid duct over the buccal fat pad to supply the buccinators and muscles of the upper lip and nose.[14] The lower buccal trunk leaves the parotid lower down at about the level of the earlobe and then transitions from deep to the underside of the SMAS in close association with the masseteric ligament.[15]

The *marginal mandibular* nerve exits the lower part of the parotid gland and runs around the angle of the mandible and then in an anterior direction above the inferior border of the mandible. Over most of its course, the mandibular branch is mobile and superficial just deep to the platysma where it can be easily injured during surgical and non-surgical procedures in the lower face. The mandibular nerve innervates the lip depressors.

The temporal and mandibular branches are the most significant in terms of permanent neurological deficit because of the lack of cross innervation of their target muscle.[7] Finally, the *cervical* branch passes into the neck at the level of the hyoid bone to innervate the platysma muscle.

CENTRAL AND PERIPHERAL FACIAL PARALYSIS

Facial paralysis can occur within the central nervous system (i.e. motor cortex or brainstem), within the temporal bone, or distal to the temporal bone.

A peripheral facial nerve injury is characterised by paralysis of the muscles of expression on the affected side of the face. Because the facial nerve conveys various fibre components that leave the main trunk of the nerve at different sites, the clinical presentation of facial paralysis is subject to subtle variations marked by associated disturbances of taste, lacrimation, salivation, etc.[2]

The facial motor nucleus contains the cell bodies of lower motor neurons which innervate ipsilateral muscles of facial expression. The axons of these neurons reach their target muscles through the facial nerve. These motor neurons are innervated in turn by upper motor neurons in the primary somatomotor cortex (precentral gyrus), whose axons enter the corticonuclear fibre bundles to reach the facial motor nucleus in the brainstem.

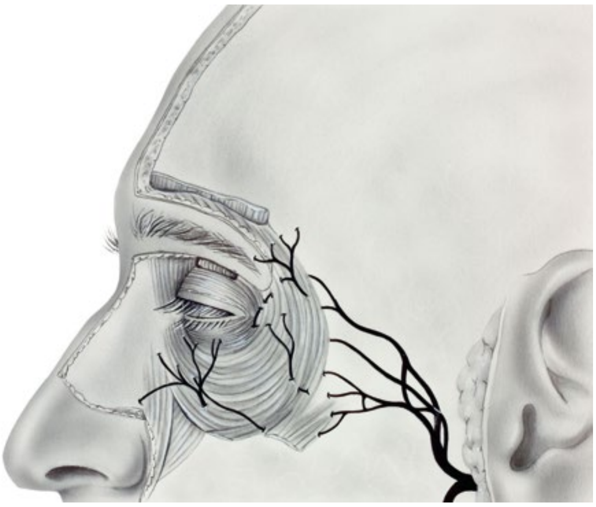
Upper motor neuron (supranuclear) lesions clinically present with paralysis of the contralateral muscles of facial expression in the lower half of the face with bilateral sparing of the frontalis function because cortical fibres decussate prior to innervating the lower motor neurons.[17]

Lower motor neuron (infranuclear) lesions present with complete paralysis of the ipsilateral muscles. Depending on the site of the lesion, additional defects may be present such as decreased lacrimation and salivation or loss of taste in the anterior two-thirds of the tongue (chorda tympani).

CONCLUSION

The face is one of the most complex and dynamic areas of the human body. A plethora of invasive and non-invasive procures have been introduced to reduce signs of ageing and to restore the youthful appearance of the face.[18] The success of each one of those procedures is directly related to the understanding of the underlying three-dimensional facial anatomy. This issue's article focuses on the function and course of the facial nerve and its branches. It highlights the danger zones and relevant landmarks, particularly in the anterior face and above the zygomatic arch where the nerve transitions to more superficial layers of the face.

Any medical intervention including medical aesthetic treatments and procedures such as injecting filling agents or using suspension threads, HA and non-HA facial volumisers (e.g. autologous fat) can potentially be associated with higher or lower risks. Anatomy can help the practitioner minimise the associated risks and also make them aware of the clinical presentation of potential complications and adverse events should they arise. **AM**



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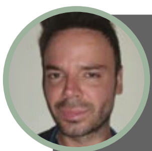

Dr Sotirios Foutsizoglou developed a particular interest in anatomy during his time working in plastic and reconstructive surgery in the NHS. He became heavily involved in teaching anatomy and physiology to medical students and junior doctors and has worked as an anatomy demonstrator for Imperial College. Since 2012, in his role as the lead trainer of KT Medical Aesthetics Group, he has been training practitioners in facial anatomy and advanced non-surgical treatments and procedures. He has written and lectured on facial anatomy and complications associated with injectables both nationally and internationally.