Chapter 56: Anatomy

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Parotid Gland

The parotid gland, the largest of the salivary glands, is located on the face and is palpable between the ramus of the mandible and the mastoid process (Fig. 56-1). The lateral surface of the gland is covered only by the skin and dermis of the face: thus the gland is vulnerable to injury even with superficial lacerations of the face. The medial relations of the gland (Fig. 56-2) or deep surface are buttressed by the styloid process and its associated muscles (styloglossus, stylohyoid, and stylopharyngeal) as well as the carotid sheath and its contents (internal carotid artery, internal jugular vein, and cranial nerves (CN) IX, X, and XII). The superior limit of the gland is the zygomatic arch, and the inferior boundary of the gland is the oblique anterior border of the sternocleidomastoid muscle.

The gland is often described as having a superficial and deep lobe, although the exact pattern of lobulation has been the subject of substantial debate (Davis et al, 1956). A simplified view is to think of the gland as an asymmetric dumbbell with the larger end representing the superficial lobe and the smaller end the deep lobe, with the glandular isthmus being the connection between the two. When viewed from above, the groove between the two is filled by the ramus of the mandible and its muscle coverings. The posterior groove is filled by the mastoid and posterior belly of the digastric muscle. Much of the superficial lobe lies close to the skin and is obvious when the gland is swollen, as happens with parotitis. Because of the close anatomic relationships and the fact that the gland is well encapsulated within a fascial envelope, swelling of the gland during parotitis (as in mumps) can be quite painful, particularly when the patient opens his mouth. The hinge action that occurs when the mandible is depressed compresses the swollen parotid against the mastoid process and the walls of its inelastic capsule and results in a painful masticatory process.

The main portion of the deep lobe lies adjacent to the styloid and carotid sheath structures, as just described, but when enlarged by tumor it can contact the lateral pharyngeal wall in the region of the palatine tonsil and appear clinically as a peritonsillar mass.

Clinical considerations

The surgical concept of the parotid gland is of a structure that contains two lobes: superficial and deep. The plane between the two lobes is defined by the facial nerve as it exits the stylomastoid foramen and courses anteriorly through the gland to innervate the fascial muscles of expression. Surgically removing the superficial lobe is often the recommended approach for diagnosis and treatment of tumors of the parotid gland. Crucial to successful removal of the superficial lobe is the accurate identification and preservation of the facial nerve.

The only constant landmark to the location of the facial nerve is the stylomastoid foramen from which the nerve exists the skull base. Although the nerve can and often is displaced by large tumors of the parotid gland, it usually can be identified without dissecting the mastoid tip. The key to identifying the facial nerve successfully is good exposure. The incision starts anteriorly in the pretragal skin creases and extends inferiorly down to the lobule where is is gently curved posteriorly, approximately a centimeter over the mastoid tip before tracing the anterior border of the sternocleidomastoid muscle. It is then extended anteriorly approximately two fingers' breadth beneath the inferior ramus of the mandible. The skin flap is elevated to expose the entire gland. This usually results in an exposure from the zygomatic arch to the midportion of the posterior belly of the digastric muscle. Careful dissection down the cartilaginous external auditory canal medially is then performed. Care should be taken to avoid dissecting into a "hole". The anterior border of the sternocleidomastoid muscle insertion onto the mastoid tip should be developed to increase exposure. Eventually the cartilaginous pointer will be identified; the facial nerve lies inferior and slightly deeper to the pointer. It is helpful to use an operating headlight and low-power magnifying loops for this portion of the procedure. Once the nerve is identified visually it is important that confirmation be obtained with a single low-power electrical stimulation. The nerve trunk is then traced anteriorly with removal of the so-called superficial lobe. Using a small, pointed hemostat, tunnels are created over the nerve branches and then connected, allowing preservation of the nerve. It is critical that the gland be placed under traction by the surgical assistant.

Occasionally the facial nerve cannot be identified via the pointer. It then becomes necessary to use an alternative method. All of the alternatives with the exception of localization within the mastoid tip via a mastoidectomy require identification of a branch of the facial nerve and retrograde dissection back to the main trunk. Perhaps the most reliable alternative is identifying mandibularis branch as it crosses the facial vein. The ophthalmic and buccal branches are also potential candidates for identification and subsequent retrograde tracing.

Parotid duct

Although the parotid duct usually appears to originate from the superficial lobe, its origin is in fact frequently more complicated. Davis et al (1956) have described the formation of the parotid duct as arising from a varied pattern of extraglandular ductules. These ductules may arise from the superficial lobe, the deep lobe, or both, before fusing to form the substance of the parotid duct. The duct traverses the surface of the masseter muscle and crosses the anterior aspect of the mandible approximately a fingers' breadth below the zygomatic process. At this point the duct abruptly turns medially to pierce the buccinator muscle and the buccal fat pad to enter the oral mucosa, which it penetrates at approximately the level of the second maxillary molar.

Surface relationships of the parotid gland

The lateral surface of the gland or its superficial lobe has a number of important anatomic relationships pertaining to various nerves, arteries, and veins that either emerge or enter the substance of the gland at varying points around its perimeter. If the gland is viewed as a clock face with the superior pole representing the twelve o'clock position and the inferior pole representing the six o'clock position, various structures can be seen to enter or leave the gland at these points (Fig. 56-1). At the twelve o'clock position are three structures: the auriculotemporal nerve and the superficial temporal artery and vein. At the inferior pole, or six o'clock position, the structures are the retromandibular vein and its connections with the external and internal jugular veins. Along the anterior margin of the parotid are the various branches of CN VII, which emerge from the substance of the parotid to enter the submuscular plane of the face. These include the temporal, zygomatic, buccal, mandibular, and cervical branches. A transverse facial artery and vein are also related to the anterior aspect of the parotid, located slightly superior to the parotid duct and paralleling the course into the cheek and infraorbital region. At the posterior margin of the gland the posterior auricular and occipital arteries can sometimes be identified, but more often they are buried in the parotid tissue. Superficially located at this posterior aspect of the parotid, however, is the great auricular nerve. This is a peripheral nerve made up of fibers from the roots of cervical nerves C2 and C3 and is one of the major branches of the cervical plexus. This nerve serves to supply cutaneous innfervation over the region of the mastoid and the submandibular triangle of the neck.

The contents of the parotid gland include, in addition to CN VII, the external carotid artery and the retromandibular vein. Each of these structures is discussed here.

Origin and course of the intraparotid portion of CN VII

CN VII emerges from the stylomastoid foramen to enter the substance of the parotid gland on its posteromedial surface. The site of entry into the gland is an important surgical landmark and can be found using the "tragal" pointer. If the tip of the index finger is placed at the base of the tragal cartilage and is pushed firmly against the lateral aspect of the skull, the pad of the finger tip lies between the external acoustic meatus and the mastoid process. This in effect represents the site of the stylomastoid foramen and the point at which CN VII emerges from the skull. During parotid surgery, an incision is made along the inferior margin of the external acoustic meatus. The skin is reflected to visualize the cartilage of the meatus and the bone of the mastoid tip.

If one follows the interval between the bone and cartilage medially, that is, deep into the dissection, one eventually reaches the stylomastoid foramen. The depth of the foramen from the level of the skin is approximately 25 mm. As CN VII leaves the stylomastoid foramen, it simultaneously enters the substance of the parotid gland and divides into two major trunks, the temporofacial and the cervicofacial. The branching pattern of these nerves has been studied extensively by Davis et al (1956). Their study describes six patterns of the facial nerve based on the anastomosis of individual branches. Type I occurs in approximately 13% of cases and represents no anastomosis between the five branches of CN VII: the temporal, buccal, mandibular, and cervical. The other five types show varying patterns of anastomosis between the individual branches. Although to recognize the potential for variations in anatomic patterns is important for the surgeon, committing the percentages of these to memory seems fruitless because the surgeon cannot select patients on the basis of anatomic variants. For the surgeon, Geraldine's law of anatomy prevails: "what you see is what you get" (with apologies to Flip Wilson).

The temporofacial usually is composed of the temporal, zygomatic, and buccal branches, whereas the cervicofacial comprises the mandibular and cervical branches. The trunks divide into their branches within the main body of the gland and then course distally within the superficial lobe to their respective territories on the face and neck. None of the branches traverse the deep lobe.

External carotid artery

Although the external carotid artery can be visualized at the inferior pole of the parotid gland, it may travel superiorly a few millimeters before entering the substance of the gland. The posterior auricular artery is usually given off from its posterior surface before the vessel divides into its two terminal branches, the maxillary artery and the superficial temporal artery. The maxillary artery exits the deep surface of the gland and supplies the various structures of the infratemporal fossa before entering the pterygopalatine fossa. The branches of the terminal part of the maxillary artery supply the maxillary teeth and the palatine and nasal mucosae. Chapter 35 discusses the details of these vessels. Before the superficial temporal artery leaves the superior pole of the parotid, it gives off the transverse facial artery, described previously as following the course of the parotid duct supplying the upper quadrant of the face. Chapter 18 describes the distribution and pattern of anastomosis of the superficial temporal artery in the scalp.

Venous pattern within the parotid gland

The venous structures within the parotid gland fundamentally parallel those of the parotid arteries; they consist of a superficial temporal vein and a series of veins emerging from the infratemporal fossa and the pterygoid venous plexus. The maxillary vein may be somewhat short, since it is formed from a series of tributaries rather than a single large vein crossing the infratemporal fossa, as in the case of the maxillary artery. The fusion of the maxillary and superficial temporal veins forms the retromandibular vein within the substance of the parotid. The veins usually occupy the plane between the nerve (superficially located) and the artery (located in the deep lobe). The retromandibular vein exits from the parotid near its inferior pole, where anastomosis with the external jugular vein occurs. Frequently a posterior facial vein connects with the anterior facial vein, the confluence of the two forming a common facial vein that drains into the internal jugular vein (Figs. 56-1 and 56-3). The pattern of venous anastomosis at this point varies in different individuals as well as from side to side in a single individual.

Innervation of the parotid gland

The ninth cranial nerve (CN IX) provides secretomotor function to the parotid gland after a complicated course through the temporal bone and infratemporal fossa (Fig. 56-4). The secretomotor fibers begin in the inferior salivary nucleus of the brainstem and travel with CN IX as it emerges from the jugular foramen. Here a recurrent branch, the tympanic branch (Jacobson's nerve), turns back into the skull by entering a small canal, the inferior tympanic canaliculus, which opens onto the floor of the middle ear or tympanic cavity (Fig. 56-4). The path of this nerve can be identified on most skulls by the passing of a fine bristle through the tympanic canaliculus, located in the bony septum lying between the jugular and carotid foramina, as the middle ear space through the external acoustic meatus is observed.

From the floor of the tympanic cavity, the nerve fibers enter the mucosa over the promontory and course anterosuperiorly to penetrate the bony roof of the tympanic cavity and enter the subdural space of the middle cranial fossa. It should be noted that the tympanic nerve also contains sensory fibers that are distributed to the mucosa of the middle ear.

After penetrating the roof of the tympanic cavity, the secretomotor fibers descend on the petrous ridge in the middle cranial fossa as a delicate nerve bundle, termed the *lesser petrosal nerve*. The fibers are directed toward the area of the forament spinosum and the foramen ovale and usually exit from the skull via the latter in proximity to the third division of the trigeminal nerve. Because these fibers are preganglionic parasympathetic secretomotor fibers, they synapse with the cell body of a second neuron before innervating the parotid. The accumulated cell bodies of these second-order neurons form the otic ganglion; they are the source of the postganglionic fibers for innervation of the gland. The ganglion is not always an identifiable structure attached to the mandibular division of the trigeminal nerve, but may be formed by scattered cell bodies trapped within a plexus of trigeminal nerve fibers. Postganglionic fibers from the ganglion do not form a new nerve but joint with the auriculotemporal branch of the mandibular division of the trigeminal nerve, which crosses the posterior wall of the infratemporal fossa to the region of the parotid. Most of the secretomotory fibers leave the auriculotemporal nerve and disperse within the parotid substance, so that by the time the nerve crosses the temporomandibular joint it contains only sensor fibers from the scalp.

Frey's syndrome (gustatory sweating, or auriculotemporal nerve syndrome) is familiar to most surgeons who perform parotidectomies. Following parotidectomy the regeneration of these secretomotor fibers becomes misdirected, and the fibers innervate the sweat glands of the skin. The result of these misdirected fibers is facial sweating when CN IX is stimulated during the course of eating. Ross (1970) observed increased parotid secretion after electrical stimulation of the tympanic branch of the glossopharyngeal nerve in stapedectomy patients. In a second patient population with Frey's syndrome, Ross resected the tympanic plexus and obtained a mixed result with respect to relief of the patient's symptoms. Although 2 patients had permanent cures, other patients had a return of symptoms within 30 days. This return resulted from incomplete section of the typmanic plexus with recovery of the remaining nerve fibers several days after surgery. These fibers arise as a hypotympanic nerve from the tympanic plexus near the floor of the tympanic cavity and ascent the anterior aspect of the promontory either within the mucosa or covered by thin bone. A hypotympanic branch has been described in 50% of specimens (Porto et al, 1978). Parotid atrophy has been reported in humans (Dishell, 1971) and rabbits (Wallenborn, 1968) after interruption of the tympanic plexus.

It appears clear from the current evidence that parasympathetic secretomotor fibers innervate the parotid gland solely through CN IX and that denervation of the gland results in atrophy. The parotid gland, then, contrasts with other salivary glands that appear to be more diffusely innervated.

Submandibular Gland

The submandibular gland fills the major portion of the digastric or submandibular triangle. The gland rests against the structures forming the floor of the triangle, the mylohyoid and hyoglossus muscles (Fig. 56-3). The gland has two portions: (1) a superficial lobe lying superficial to the mylohyoid and (2) a deep lobe wrapping around the posterior border of the mylohyoid muscle. The deep lobe cannot be palpated superficially in the neck but can be palpated in the floor of the mouth by a gloved finger while the other hand supports the superficial lobe. The duct of the submandibular gland (Wharton's duct) emerges from the deep lobe and courses anteriorly in the plane between the hyoglossus and mylohyoid muscles. It terminates as an elevated papilla on the floor of the mouth near the frenulum of the tongue, adjacent to the duct from the opposite side. While occupying this plane the duct is crossed twice by the lingual nerve, once on its lateral aspect near its origin and again on the medial aspect of the duct near its termination at the frenulum.

Clinical considerations

The surgical approach to removing the submandibular gland is through an incision placed approximately two fingers' breadth beneath the inferior border of the ramus of the mandible. The incision is carefully dissected down to the level of the platysmal muscle and the fascia lying immediately over the actual gland. At this level the mandibularis branch of the facial nerve is identified lying on the undersurface of the platysmal muscle and superficial on the fascia overlying the submandibular gland proper. Damage to this nerve will result in drooping of the corner of the lip. The facial vein, which lies beneath the nerve, can be used to raise the nerve out of harm's way by ligation inferior to the nerve and then subsequent dissection of the vein superiorly with the nerve trapped above the vein.

Once the facial vein is safely out of the operative field, the dissection then can proceed to identification of the posterior border of the mylohyoid muscle. Placement of a Richardson retractor on the posterior border of this muscle along with inferior traction on the gland proper brings into view the important structures that lie on the medial aspect of the gland, the lingual nerve and submandibular gland duct. With the lingual nerve usually identified as it loops into the field, the duct can safely be isolated, divided, and ligated. The facial artery is also in the field and relatively easy to identify by palpation. It is usually ligated twice during the procedure as it arises from the depths of the wound through the undersurface of the gland and over the mandible.

Sublingual Gland

The sublingual gland is a flat, oblong structure that accompanies the distal half of the submandibular duct, so the gland occupies the same plane; that is, between the mylohyoid and hyoglossus muscles (Fig. 56-3). It lies superficially in the floor of the mouth, covered only by the oral mucosa. The gland does not have a single large excretory duct but a series of ductules that open either into the floor of the mouth directly or into the submandibular duct. The submandibular duct thus serves both glands.

Innervation of the Submandibular and Sublingual Glands

The submandibular and sublingual glands are innervated by secretomotor fibers of CN VII, which are derived from the superior salivary nucleus. These fibers exit from the brainstem within the intermediary nerve rather than the motor portion of CN VII. The intermediary nerve joints CN VII within the internal acoustic meatus, and its fibers parallel the course of CN VII through the temporal bone (Fig. 56-5). On the posterior wall of the middle ear the chorda tympani branch of CN VII arises from the vertical portion of CN VII and crosses the lateral wall of the middle ear. Its course is constant as it parallels the tympanic membrane, lying between the long process of the incus and the manubrium of the malleus. Anteriorly it pierces the petrotympanic fissue of the middle ear and enters the infratemporal fossa. Here, the nerve has a short independent course before joining the lingual nerve, a branch of the mandibular division of the trigeminal nerve. The fibers follow the course of the lingual nerve until it reaches the floor of the mouth, where the fibers leave the lingual nerve to synapse in the submandibular ganglion, a parasympathetic ganglion. The ganglion is usually a prominent structure attached to the lingual nerve by a plexus of nerve fibers (Fig. 56-5). Postganglionic secretomotor fibers course directly to the submandibular gland from the ganglion, but some postganglionic fibers return to the lingual nerve and travel anteriorly in the floor of the mouth before supplying the sublingual gland.

Although the innervation of the parotid gland was seen to be quite specific - denervation resuling in glandular atrophy - the same is not true for the submandibular and sublingual glands. Sectioning of the chorda tympani does not produce atrophy of these glands and results in only partial diminution of secretion, even when combined with sectioning of the tympanic branch of the glossopharyngeal nerve.

Innervation of the Tongue

Although initially this topic may not seem to fit into the context of this chapter, it is actually quite appropriate when one considers that the tongue receives sensory innervation from the chorda tympani branch of the facial nerve, the lingual branch of the trigeminal nerve, and the terminal branch of the glossopharyngeal nerve.

The twelfth cranial nerve supplies al of the tongue's musculature by fibers beginning in the hypoglossal nucleus of the medulla. However, the sensory innervation of the tongue is topographically divided into the posterior one third supplied by the glossopharyngeal nerve (CN IX) and the anterior two thirds supplied by the lingual and chorda tympani nerves. In the posterior third the glossopharyngeal nerve supplies both special visceral afferents responsible for taste and general visceral afferents concerned with touch and the gag reflex. The majority of the taste buds in the posterior third of the tongue are located in the epithelium lining the circumvallate papillae, although others can be found in the mucosa of the valleculae and the epiglottis. The peripheral processes of both modalities, taste and touch, have the cell bodies of their neurons in the inferior ganglion of the glossopharyngeal nerve, which is located on the nerve at the level of the jugular foramen. The central processes for both taste and touch project to the nucleus solitarius in the pons.

In the anterior two thirds of the tongue, touch and taste sensations are carried by two different nerves, the lingual and the chorda tympani, respectively. The general sensations of touch, pain, and temperature are carried by fibers via the lingual nerve; the fibers ascent the infratemporal fossa to the foramen ovale, where they join with other fibers of the mandibular division of the trigeminal nerve. The peripheral processes of these neurons have their cell bodies located in the semilunar ganglion of the trigeminal nerve. Central processes project to the nucleus of the spinal tract of CN V in the case of pain and temperature fibers, whereas touch fibers project to the main sensory nucleus of CN V. Taste buds in the anterior two thirds of the tongue are locate either in the foliate papillae along the lateral aspect of the tongue or in fungiform papillae, which are more diffusely distributed in the mucosa. Afferent fibers from the taste buds travel posteriorly along the lingual nerve until the junction with the chorda tympani near the roof of the infratemporal fossa. The fibers follow the course of the chorda tympani through the middle ear and join the facial nerve on the posterior wall of the tympanic cavity. Following the facial canal, the fibers reach their cell bodies in the geniculate ganglion before projecting centrally via the intermediary nerve to the nucleus solitarius in the pons.

The importance of neuroanatomic pathways is obvious in understanding the various clinical deficits exhibited by patients after either a central pontomedullary lesion or a peripheral trauma affecting the pathways of CN V, VII, or IX.

Anatomic Planes in the Floor of the Mouth

The surgical approaches to the salivary glands in the floor of the mouth may involve either an intraoral route or an external approach through the submandibular triangle of the neck. Regardless of the approach chosen, the anatomic relationships are fundamentally the same. The surgeon must anticipate anatomic structure during surgical dissection. Memorizing anatomic detail seems tedious, but sometimes simple organizational techniques can facilitate learning. In the floor of the mouth the keys to these relationships are the mylohyoid and the hyoglossus muscles, which form vertical planes for the passage of the neurovascular bundle that is related either superficial or deep to these muscles (Fig. 56-6). In this manner, three planes can be described: the first, superficial to the mylohyoid; the second, superficial to the hyoglossus; and the third, deep to the hyoglossus.

Plane that is superficial to the mylohyoid muscle

The relationships of the mylohyoid muscle are in fact the contents of the submandibular triangle of the neck. Bounded by the two bellies of the digastric and the body of the mandible, the triangle forms a three-dimensional space rather than a flat triangle. The skin and platysma close the roof (lateral wall) of the triangle, whereas the mylohyoid and hyoglossus muscles form the floor (medial wall). Superficial to the mylohyoid are the submandibular gland, associated lymph nodes, the facial artery and vein, and the motor nerve to both the mylohyoid muscle and the anterior belly of the digastric muscle. One of the most superficial structures in the space is the mandibular branch of the facial nerve, which after emerging from the parotid usually arcs below the mandible before ascending onto the face again near the anterior part of the triangle. Chapter 18 discusses this nerve's importance to the innervation of the muscles of the lower lip.

Plane that is superficial to the hyoglossus muscle

The structures related to the hyoglossus muscle might also be described as lying deep to the mylohyoid; in effect, they occupy the plane between the two muscles. The deep lobe of the submandibular gland separates these muscles by folding around the posterior border of the mylohyoid before sending the submandibular duct anteriorly to the frenulum of the tongue. The sublingual gland surrounds the duct as it lies against the anterior part of the hyoglossus muscle. In addition to the duct, two nerves occupy this plane, the lingual and CN XII (the hypoglossal nerve). The hypoglossal nerve always courses along the most inferior part of the plane between the two muscles. The lingual nerve enters the floor of the mouth, superior to the submandibular duct, and crosses it laterally before ascending on the medial surface of the duct adjacent to the hyoglossus muscle.

Plane that is deep to the hyoglossus muscle

Three structures occupy the plane that is deep to the hyoglossus muscle: the lingual artery, the stylohyoid ligament attaching to the lesser cornu of the hyoid bone, and CN IX (glossopharyngeal nerve) (Fig. 56-6). The nerve and ligament are not seen in Fig. 56-6 because they have terminated posterior to the plane of the section.

The three relationships just described provide an inventory of structures the surgeon should be able to predict during surgical dissection. Whether the challenge is a simple exploration of the floor of the mouth to remove a ductal occlusion or a complicated hemiglossectomy, the anatomy is the same.