CHAPTER

Cornerstones, Milestones, Stepping-stones and Stones in the History of Salivary Glands

Abraham M. Baruchin

CHAPTER OUTLINE

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Sialoendoscopy is looked upon as one of the modern discoveries. However, in this review we will trace the idea of removing sialoliths’ back to its roots and review its progress until it attained its modern shape.

By the time our forebears, in the Near East, reached the level at which they were recording their surgical concepts, their sophistication leaves us abashed as well as amused. The first written record containing medical information date about 2500 B.C. Clay tablets from this time have been discovered in Mesopotamia.

The earliest references to saliva medical conditions probably originate in the ancient Mesopotamia, in the 7th century BC., the Assyrian king Asurbanipal assembled a library of manuscripts of vast scale (aka the Assyrian Herbarium which, gives a list of some 700 medicinal and semi-medicinal plants arranged according to use and application), including Sumerian and Akkadian medical stone tables dating to 2000 B.C. Specifically, according to Thompson1, belladonna was mentioned as useful remedy “to stop the flow of saliva”.

Medicine in ancient Egypt was but one aspect of an advanced civilization. It was not practiced by witch doctors as in primitive tribes, with mixture of magic, herbal remedy, and superstitious beliefs. This was acknowledged by Homer in the Odyssey: “In Egypt, the men are more skilled in Medicine than any of human kind”.

Several medical papyri have survived the ages. They contain prescriptions for treating diseases of the lungs, liver, stomach, bladder and for various afflictions of the head and scalp. The Egyptians conception of the human body, then, was as a network of interconnecting channels and analogous to the branches of the Nile and the artificial canals of their own country. Notions of physiology and disease were all an-
chored in the concept of the heart as the center of the organism. The heart was one's partner; it spoke to a person in his or her solitude. It was at the same time the engine of all the bodily functions, not only of one cardinal function, the circulation, as modern science revealed. From the heart proceeded channels (metu) linking all parts of the body together. These channels, the Egyptians believed, conveyed not only the blood, but also air (reaching the heart from the nose, they thought), tears, saliva, mucus, sperm, urine, nutriment and feces, as well as harmful substances conceived to be the agents of pain and illness. Not only blood vessels were considered as metu, but also the respiratory tract, tear duct, ducts of various glands, spermatic duct, the muscles, tendons and ligaments. According to the Berlin Papyrus which was acquired by Giuseppe Passalacqua in Seqqara and was sold on to Friedrich Wilhelm IV of Prussia with other objects in 1827 for the Berlin Museum. The style indicates that it is 19th Dynasty and Wreszinski translated it into German in 1909. An ancient report reads as follows: “The patient suffers a great epigastric pain. He feels a heavy, hot and inflamed body. He complains of being unable to tolerate his clothes and feels they do not warm him. He feels thirsty during the night. His saliva has the taste of unripe fruits. His muscles pain him as if he walked for a long distance.”

Votive tablets found during the excavation of shrines of the Graeco-Roman god of medicine (Asklepios or Aesculapius) associate the healing of superficial lesions with contact with the oral cavity of non-poisonous serpents. It is suggested by Angeletti and Agrimi, 3 that this may have been the empirical exploitation of the healing properties of salivary growth factors. By immunohistochemistry and immunoblotting it was demonstrated the expression of the epidermal growth factor and its receptor in the oral, upper digestive, and salivary epithelia of Elaphe quatuorlineata, a species probably used in healing rituals.

Micheli-Pellegrini 4 divide the historical development of anatomical knowledge of the salivary glands into two periods:

A. the early period
- From the fifth century B.C., to the seventeenth century A.D.

B. the salivary period
- From the seventeenth century to our days.

The early period
(Fifth century B.C. — early early seventeenth century A.D.)

Many foundations of modern Western medicine lie in Classical Greece from about 800 B.C.E. to about 200 A.D. During this period, Greek medicine departed from the divine and mystical and moved toward observation and logical reasoning. These ideas spread throughout the Mediterranean world and as far east as India, and their influence has remained strong in the West to this day.

Hippocrates: (470 B.C. — 410 B.C.)

The accepted explanation in his writings that saliva was a “humor” which circulate in the body as did bile, gastric juice and urine persisted unchanged into the Renaissance. It was only by repeated investigations aided by later microscope studies that the true origin and function of the salivary glands was finally revealed. Hippocrates described mumps as an illness accompanied by swelling of the ear and painful enlargement of the testes, either unilaterally or bilaterally. Swellings appeared about the ears.... In all cases they disappeared without giving trouble, neither did any of them come to suppuration, as is common in swellings from other causes. They were of a lax, large, diffused character, without inflammation or pain.... In some instances earlier, and in others later, inflammations of pain seized sometimes one of the testicles, and sometimes both. Hippocrates also described ranulas and thought that they were secondary to inflammation fascinating clinical entity, this syndrome has received scant atten-
Aulus (Aurelius) Cornelius Celsus (25 B.C. — 50 A.D.) in book 6 Chapter 16 of his work: De re medicina described the parotis and in book 7 the clinical appearance of the ranula.5

Galen of Pergamum Galen (129 A.D. — 200 A.D.). According to Galen’s theory the blood was filtered in the brain, so that its impurities could be discharged through the cribriform plate (a lamina of the ethmoidal bone so-called because it is akin to a sieve — *cribrum* in Latin) giving rise to tears, saliva, and mucus and sweat. He published many books, which he had to rewrite after his library was destroyed by fire in 191. This book became extremely influential in the Middle Ages, when they were well-read in both the Byzantine empire and the Arab world. Great scientists like Ibn Sina, Ibn Rushd and Vesalius based their researches on the foundations laid by Galen.

Oribasius (325—400 A.D.) was an encyclopedist and healer from Pergamon (like Galen). He was a friend, physician and adviser to Emperor Julian ‘the Apostate’ (332—363 A.D.). Julian, in any case, encouraged Oribasius to compile his Medical Encyclopedia of 70 or so books, about a third of which survives, and in which he carefully and meticulously quotes earlier authors thus allowing us to glimpse the surprising richness and knowledge of ancient medicine. He refers to calcareous concentrations in the mouth and to the ways for their removal.

Alexander, a Roman physician of the in the Second Century described “A person who spat a stone out his mouth”.

Gentile di Fogliano (1412) and Alessandro Benedetti (1490) reported similar cases of probable sialolithiasis in the submandibular glands.

Alessandro Achillini (1463—1512) was a celebrated lecturer in Medicine and Philosophy at Bologna and Padua. He was the author of Carports Humani Anatomia and Anatomicae Annotationes, in which he was the first to describe the malleus and incus and demonstrated that there are seven tarsal bones. He rediscovered the fornix and the infundibulum. He also described, exactly, the ducts of the submaxillary salivary glands — a discovery generally attributed to the Englishman Thomas Wharton (1614—1673). (Fig. 1-1)6

Lorenz Heister (Heisterus) (1683—1758) A German surgeon attributed the first reports of submandibular sialolithiasis to Fabricius di Acquapendente, Domenico Marchetti, and Nicholas Tulpius immortalized by Rembrandt’s painting: Anatomy Lesson of Dr. Tulip.6

Felix Platter (1536—1614) was the first to report parotid calculi he removed from a Bourgogne nobleman in 1560.

**The Salivary Period**

Only after the discoveries between 1634 and 1666, does the real history of sialolithiasis shifts from anecdotal case reports to more precise anatomic and scientific description.
Marcello Malpighi (1628—1694) was a pioneer in the use of the microscope, which, as a compound of two lenses, had been invented around 1600 by Zacharias Jansen and improved upon by Galileo Galilei. Further improvements were made by Anton von Leuwenhoek (1632—1727) of Delft and Jan Swammerdam (1637—1680) of Amsterdam. In Malpighi’s series of treatises published in 1665—6, [De viscerum structura], one finds the first definitive summary of all the knowledge of the salivary glands from ancient time to the seventeenth century.9

Antonio Maria Valsalva (1666—1723) (Fig. 1-2) In his impressive De Aure Humana Tractatus he showed clearly the parotid gland and Stensen’s duct (Fig. 1-3).

Bartolomeo Eustachi (Eustachius) (1500—1574). In his Anatomical Engravings which, though completed in 1552, nine years after the impression of the work of Vesalius, the author was unable to publish. First communicated to the world in 1714 by G. M. Lancisi. Afterwards in 1744 by Cajetan Petrioli, again in 1744 by B. S. Albinus, and subsequently at Bonn in 1790, the engravings show that Eustachius had dissected with the greatest care and diligence, and taken the utmost pains to give just views of the shape, size and relative position of the organs of the human body. The facts illustrated by these figures are so important that it has been said that if the author had been fortunate enough to publish them, anatomy would have attained the perfection of the 18th century two centuries earlier at least. Their seclusion for that period in the papal library has given celebrity to many names which would have been known only in the verification of the discoveries of Eustachius.10

The Salivary Glands

The term “Salivary Glands” was coined probably by Andreas Vesalius or Andreas Vesal (1514—1564). However, Jean Riolan, (1580—1657) was the first to identify the glandular mass of the Protid (1648). Julius Caesarius 1561—1616)) described in his book Pentaesthesion (1609) the opening of the parotid into the oral cavity.

Ambroise Pare believed the parotid to be an emunctory or excretory organ of the brain while Thomas Bartholin(1616—1680) (Fig. 1-4) who is known also for his work on the sublingual gland described in his Anatomia Reformata, thought the parotid duct was a ligament of a preauricular gland. Seguignal in 1690 is credited for the first description of of a parotid gland enlarged by asialolith obstructing the Stensen’s duct.

Niels Stensen — Nicolaus Steno (1638—1686) (Fig. 1-5), on 7 April 1660, Stensen aged 22 years, dissected the head of a sheep, making his first discovery by finding the excretory duct of the salivary gland. At once modest and full
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of a beginner’s joy in research, he tells of it in a letter to Thomas Bartholin: “Having been allowed to dissect on my own, I succeeded in the first sheep’s head which I purchased and dissected by myself in the study hall on 7 April in finding a duct which — as far as I know — has not previously been described. It was my intention after removing the ordinary outer parts to do a section of the brain when I happened to decide first to examine the vessels running through the mouth. Examining with that intention the course of the veins and arteries, by inserting a probe I observed that the point is no longer enclosed in the narrow sheath but moves freely in a spacious cavity; and pushing the instrument further forward, I at once heard it clink against the teeth themselves”.

Elsewhere in his letter to Bartholin, Stensen modestly calls his discovery an inventiuncula — a small observation. In a way, it was this inventiuncula that would make him most famous, because, the duct of the parotid gland was named, by one of his Dutch friends, the Ductus stenonianus.

Stensen had of course summoned his professor — and landlord/host — Gerard Blasé (Bla-sé) (1626—1682), to show him his discovery. It was at once dismissed as a badly performed dissection. But on further reflection, Blasé claimed the duct as his own discovery and in a brief publication entitled General Medicine in the spring of 1661 laid public claim to it. The prolonged dispute about the discovery had only one result, which was to lead the young Dane on to a succession of further discoveries. Actually, Stensen stayed for only a few months in Amsterdam, probably according to plan, but like his Dutch friends he would continually return to this center of culture. He made a number of new friends during his short stay. The one he may have liked best was his contemporary fellow student Jan Swammerdam, one of the truly great zoologists, and one of the first to use a microscope in scientific studies. Among the professors he particularly attached himself to was Frangois, De Le Вол or Franciscus Sylvius (1614—1672), who had not only distinguished himself with his contributions to the knowledge of glands and the brain but was also an
admired and inspiring academic teacher. Sylvius and his followers studied the digestive juices, with which they recognized saliva, and viewed digestion as a kind of fermenting process. He may also have organized the first university.

Stensen appeared before the public as an independent research worker with his dissertation: “On the glands of the mouth and recently discovered ducts”, of 6—9 July 1661, with van Horne presiding. He described factually and fully in this paper his old discovery of Steensen’s duct, but went much further in announcing a number of other gland discoveries and discussing the problem of the general importance of glands. Quietly, he now began to assemble these and other findings on glands in a publication, Anatomical Observations, which appeared early in 1662. Gerard Blasé made a few last desperate efforts to assert his claim, and was briefly refuted by Stensen in his Precursor to an Apology of 1663, in which he demonstrated the difference between his duct and the one described by Blasé.11, 12

In 1704 Georgio Baglivi (1668—1707) confused parotitis with otitis, however his was the first description of referred pain to adjacent structure such as ear and head. Philippe Frédéric Blandin (1798—1849) and Anton Nuhn (1814—1889) in 1826 and 1845 discovered the anterior lingual glands.

Surgery

From 1650—1750, in view of the improved knowledge of anatomy of the salivary glands, refined surgical techniques were developed. However these were limited to the treatment of ranulas and sialolithiasis. Lorenz Heister (Heisterus) in 1765 gave the first account of primitive parotidectomy. The concept of surgical excision of a parotid tumor has been attributed to Ambroise Bertrand in 1802 (however, he performed only partial excision of the parotid gland as were most of the parotidectomies between 1600—1800). The initial applications of this surgery included a rather extensive approach, causing serious disfiguration and disability. Deguise in 1811 suggested double puncture of salivary fistulae, Morestin in 1818 tried ligation of the proximal stump of Stensen’s duct in order to atrophyze the gland and stop draining fistula. In 1830 Langebeck suggested meticulous dissection of the duct with reanastomosis. Jean Zule‘ma Amussat (1796—1856) is credited for total submandibular gland resection. Velpeau (1795—1867) (Fig. 38) in his book: “Nouveaux elements de parotids operatoire” mentioned several surgeons who performed parotidectomy Carl Al-fred Caspar von Siebold (1736—1807) performed In 1781 a total parotidectomy with some attempt to preserve the facial nerve. While Beclard, Gensoul, and Lisfranc followed by facial paralysis. Johann Ferdinand Heyfelder (1798—1869) who administered the first ether anesthetic in Germany at the Erlangen University Hospital on January 24, 1847. He was able, in 1825, to avoid facial paralysis in a parotidectomy. Velpeau himself devised a technique for locating the trunk of the facial nerve. Sedillot and Berard in 1847 performed total parotidectomy without carotid ligation but still severed the facial nerve. By approximately 1850, the focus shifted toward dissection and the intimate relationship of the facial nerve and the parotid gland John Eric Erichsen (1818—1896) in 1869 underscored the importance of avoiding the wounding of the hard portion of the 7th nerve “one can avoid it by dissecting parallel to the tumor. According to Brunetti et al. the first total parotidectomy with preservation of facial nerve was carries by Codreanu in 1892. George McClellan, (1796—1847) shares with Valentine Mott, of New York, and John C. Warren, of Boston, the credit of establishing many procedures new in this country. He did more than any other surgeon by the number and success of his operations to establish completely, as safe and feasible, the removal of the parotid gland. John C. Warren (1778—1856) was the first to use ether inhalation anesthesia during his resection of a parotid tumor in Boston in 184613.
Dr. Phillip Syng Physick (1768—1837) Known as the “Father of American Surgery”, Dr. Philip Syng Physick was on the medical staff of Pennsylvania Hospital from 1794 until 1816. Two of his more famous operations occurred on James Hayes in 1805 and 1806 during which he removed two large parotid gland tumors from Hayes’ cheek (the larger, seven-pound tumor was preserved, and is still part of the Historic Collections14. Grafting of the facial nerve after resection was attempted in the early 1950s. Other technological advances permitted surgeons to perform increasingly complex and difficult operations.

Sialography

The discovery in 1895 of X-rays made it possible to visualize the human skeleton and any deformations thereof but it remained impossible to detect the organs and the vascular system using these rays. Étienne-Jules Marey (1830—1904) was chronophotographer & physiologist. His researches were followed up by Bull and Nogues at the Institut Marey, where they made microscopic, X-ray and high-speed analysis films. Following the discovery of x-rays in 1895 he suggested the use of radiopaque metals to outline glandular ducts and vessels.15 The first sialographic procedure is credited to Dr Arcelin a French doctor who injected in 1912 a submandibular duct with a bismuth solution and obtained overhead radiographs. The use of bismuth salts was discontinued because of cases of bismuth poisoning. Mercury was used in 1904 for the first sialogram reported (Charpy and Poirer, 1904). Both water-soluble and oil-soluble contrast media have been used, with water-soluble media currently preferred.16 The use of bismuth salts was discontinued because of cases of bismuth poisoning. In 1901 Marcel Guerbet and Laurent Lafay developed Lipiodol® a stable iodinated oil (first used for syphilis), the opacifying properties of which were discovered by chance in 1918 to produce the very first organ-ic, iodinated contrast agent. Dr Jean Athanse Sicard (1872—1929) will be remembered as the one who introduced it. Barraud is said to have discovered the advantage of this substance by injecting Lipiodol, instead of water in order to dilate the Stensen’s duct in a case of sialolithiasis.

Hermann Küttnner (1870—1932) (Fig. 1-6), who was professor in Marburg and Breslau, and who as representative of the Red Cross took part in the Greek-Turkish, Boer and Boxer Wars, has himself made some important contributions to the subject (he successfully grafted bones from ape to man). Most prominent among his collaborators were Borchard, Stieda, Schüller, and Tietze, who all made names for themselves in their particular fields. Kuttner in 1901, described parotid calculi as rarity and was also the first to mention the diagnostic value of roentgen rays in detecting salivary calculi.18

Examination with sialography was popularized in different countries in 1925 and 1926 by T. Barsony, Wiskowsky and D.B. Carlsten and Uslenghi respectively.19—22 During the next seven or so decades, technical refinements were made, including fluoroscopy with spot images, subtraction radiography, and tomography and the whole field of endoscopy.
References

The parotid gland has an exceptional position under the major salivary glands. It is not only penetrated by major blood vessels and nerves of the head, it is also divided by a strong capsule, which somewhat limits an enlargement in case of inflammatory or space-occupying processes.

1. Regional Formation/Classification

The parotid gland lies topographically in the parotideomasseteric region, which is defined superiorly by the zygomatic arch, posteriorly by the mastoid process, the tragus and the external auditory canal, inferiorly by the margin of the mandible and anteriorly by the front margin of the masseter muscle. A lamella of connective tissue divides the parotid gland into two distinctive layers, superficial and deep, through which the facial nerve branches run. Medially the parotideomasseteric region merges with the retromandibular fossa (Regio faciei parot.), which contains soft connective tissue, and passes medially into the peripharyngeal space and dorsally into the infratemporal fossa. The parotid gland extends into the retromandibular fossa up to the fan of muscles arising from the styloid process, and halts before reaching the pharynx wall (Fig. 2-1).

The ventral extension of the parotideomasseteric region merges gradually with the buccal region. The later extends from the anterior margin of the masseter muscle to the fascial muscles and is mostly filled with the corpus adiposum buccae (buccal pad of fat), the Bichat’s fat plug.

2. The Parotid Region

The parotid gland is roughly triangular in shape. The superior margin generally lies a finger width (1.5—2 cm) beneath the inferior mar-
gin of the zygomatic arch. The gland borders dorsally on the mastoid process, the tragus of the outer ear and the sternocleidomastoid muscle whose superficial fascia merges with the body the gland. The parotid gland forms inferiorly a triangular lobe (Lobus colli), which extends beyond the margin of the mandible down to the platysma.

Within the gland a superior and inferior duct converge to produce the tough excretory duct (parotid duct) which leaves the gland, and follows a course over the masseter muscle towards the buccal cavity, often accompanied by gland tissue. This excess tissue frequently forms a lobe of gland (accessory parotid gland), which varies in size and may accompany the excretory duct to its orifice. The parotid duct reflects at the anterior margin of the masseter muscle at an angle of 90° inwards and then proceeds reflecting anteriorly at the groove of the corpus adiposum buccae until it reaches the oral vestibule at the height of the second upper molar. There it penetrates the buccinator muscle and builds a small papilla at the mucosa (buccal salivary papilla). Frequently many small glands can be found at the orifice (buccal glands), which belong functionally to the mucosa. Typically the course of the parotid duct is horizontal, running approximately 2 cm below the zygomatic arch and parallel to a projection-line, from the onset of the earlobe to the carmine of the upper lip.

The parotid duct is about 5—6 cm long and the diameter varies between 0.5 and 2.3 mm. In the vicinity of the gland and the orifice the diameter averages 1.4 mm, narrowing to approximately 1.2 mm as the duct penetrates the buccinator muscle. The narrowest point is the
orifice itself. The diameter at this point is usually 0.5 mm or less (J. Zenk et al., 1998).

The parotideomasseteric fascia is very dense and consists of various types of connective tissue, mainly collagen-fibers. It adheres strongly to the capsule of the gland, protruding into the gland tissue as lamella and forming lobes which make it impossible to dissect the gland from its capsule. The capsule of the gland also adheres to the fascia of the neighboring muscles particularly the masseter and the sternocleidomastoid muscle.

An exception is the cervical lobe (Lobus colli) which has no connections to the fascia of the nearby muscles (stylohyoid muscle, posterior belly of the digastric muscle and platysma). At the retromandibular fossa, the gland is limited by soft lamellae of connective tissue from the peri-pharyngeal space, the fasciae of the stylohyoidal, stylopharyngeal and styloglossal muscles, and strands of vessels and nerves running through this region (external carotid artery, internal jugular vein, cranial nerves, lymphatic vessels) (Fig. 2-2).

3. Conduction Pathways Of The Parotid Region

3.1. Nerves

The sensory perception of the skin covering the parotid fossa originates from the great auricular nerve which rises perpendicular from the cervical plexus, to the anterior of the auditory canal where it then fans out over the parotid gland.

The auriculotemporal nerve arises from the mandibular division of the trigeminal nerve, enters the parotid fossa behind the neck of the mandible and leaves it at the superior margin of the parotid gland; it then follows a vertical path together with the superficial temporal artery and vein towards the parietal skin.

The most important nerve of the region is the facial nerve (N. VII), which enters the parotid fossa where it leaves the stylomastoidal foramen and moves ventrally in a line which can be drawn from the external auditory canal to the mandibular angle. The nerve then divides into a trunk that runs inferiorly (cervical-facial part) and a trunk that reflects antero-superiorly (temporal-facial part), laterally crossing the large vessels proceeding through the gland (external carotid artery and retro-mandibular vein). The exit point of the facial nerve from the stylomastoid foramen can easily be defined using the internal projection of the tragus as “pointer”. The exit point usually lies centrally between the “pointer” and the stylohyoidal process. The subdivision of the facial nerve into the two main-branches can be defined according to Eyries (1972) as follows;
the first line runs from the tragus-pointer to the mandibular angle (T-G in Fig. 2-3) the second from the mastoidal process to the middle of the mandibular ramus (M-M in Fig. 2-3). The intersection of these two lines (F in Fig. 2-3) marks in about 70% of cases the point in which the facial nerve divides within the parotis.

The superior main-branch of the facial nerve divides rapidly into relatively thin, closely approximated temporal and frontal branches, which leave the parotid gland below the zygomatic arch, over which they then cross diagonally to reach the mimetic muscles near the line of the hair, for which they are responsible.

The distance from the external ear and tragus varies, but is usually under 1.5—2 cm (M.E. Wigand et al., 1997) (Fig. 2-4). In order to avoid injury to the Facial nerve one should choose an incision which preserves the subcutaneous fat-pad lying laterally to the temporal fascia.

The two main branches, and the finer branches of the facial nerve; which anastomose with one another to form a coarsely meshed network (parotid plexus); lie within the same plane in the parotid gland and divide the gland into two layers. The superficial layer is relatively thin, the deeper layer together with the retromandibular fossa portion of the gland takes much more space. The temporal-facial part of the VII nerve divides immediately into numerous branches, which run diagonally to the superior margin of the parotid gland where they exit at the parotid fossa. The branches reaching the farthest cranially are the temporal-frontal branches which cross over the zygomatic arch and then approach the underside of the auricular anterior muscle, the frontal belly of the occipital frontal muscle and the orbicular muscle of eye (superior parts until the palpable fissure), which they innervate (somatomotoric). A second group builds the zygomatic branches, which run at the height of the zygomatic arch and supply the inferior part of the orbicular muscle of the eye and zygomatic muscles.

The first divisions of the inferior main facial branch (cervical-facial part) are the buccal branches of the facial nerve, which lie near the masseter muscle, and irradiate inferiorly at the mimetic muscles of the inferior facial region (orbicular and buccinator muscles, and levator muscle at the angle of mouth). The superior branch of this fan shaped system, also known

Fig. 2-3. The localization of the main facial trunk and its point of bifurcation into the two main branches as described from Eyries (M.E. Wigand et al., 1997)

Fig. 2-4. The path of the temporal-frontal branches of the facial nerve in the pre-auricular region. Marked are the variable pathways of the temporal (T) and the frontal (F) branches. Two dimensions were measured (a = distance between lateral canthus and superior margin of auricle, b = distance between lateral canthus and tragus-helix notsch) (M.E. Wigand et al., 1997)
INTRODUCTION

Salivary gland surgery for benign tumours is a traditional surgery which was not changed during decades. The direction in all the surgical fields is traced towards minimal and less invasive procedures.

The aim of this chapter is to review the new conservative procedures and the traditional surgery for benign surgery of the major salivary glands. We also include in this chapter intraoperative facial nerve monitoring due to the importance and the needs of these innovative techniques.

INTRAOPERATIVE MONITORING OF THE FACIAL NERVE IN PAROTID GLAND SURGERY

Intraoperative neurophysiological monitoring has been used with an increasing frequency in thyroid gland surgery as well as in cerebellopontine angle surgery. Some authors also recommend the regular use of neuromonitoring in middle ear surgery for protection of the facial nerve.1

Concerning parotid gland surgery there are still many divergent opinions. Whereas many authors consider the intraoperative monitoring of the facial nerve useful in difficult cases such as revisional surgery there is still a lot of discussion about its necessity in routine parotid gland surgery.2,3
According to current studies, the rate of postoperative permanent facial paresis following removal of benign parotid tumours is 3 to 5% and the rate of temporary postoperative functional deficits of the facial nerve is as high as 8 to 65%. Even temporary paresis carries — not to mention the esthetic disfigurement of the patient — the risk of permanent corneal damage due to insufficient eyelid closure and ought to be avoided if possible.

The intraoperative neuromonitoring of the facial nerve facilitates the identification of the nerve and allows a constant supervision of neural function. Arguments frequently mentioned against the routine use of neuromonitoring are the additional time required and the possible lack of accuracy. Some authors fear that the routine use of neuromonitoring may lead to a situation where younger surgeons would not be able anymore to perform parotid surgery without monitoring or where surgeons not using a monitoring device may expose themselves to possible legal problems. Other authors are afraid that the surgeon, due to a false sense of security, might be tempted to work faster and not careful enough.

Facial nerve monitoring may be performed with different electromyography devices. The Neurosign-100 (Inomed) and the Nerve Integrity Monitor-2 (Xomed-Treace) are frequently used systems. Both units have two channels and an electric stimulator. After the patient is under general anesthesia, the unipolar needle electrodes are inserted subcutaneously in the frontalis muscle, the orbicularis oculi muscle and the orbicularis oris muscle (Figs. 4-1 and 4-2). The electrodes are connected with the preamplifier (headbox) and the monitoring device

Fig. 4-1. Monopolar needle electrodes and coaxial bipolar stimulation probe used in facial nerve monitoring

Fig. 4-2. Needle electrodes inserted in the frontalis, the orbicularis oculi and the orbicularis oris muscle

(Figs. 4-3 and 4-4) and the stimulation probe is attached to the monitoring unit. During surgery a continuous recording of spontaneous muscle activity takes place. The muscle activity can be visually monitored on the EMG device itself and on an additional monitor. In ad-
tion to that there is a loudspeaker where the measured activity is displayed as an audible signal during surgery.

It is important to inform the anaesthesiologist not to administer muscle relaxants after intubation of the patient.

Intraoperative electric stimulation of the facial nerve is done with a bipolar coaxial probe under constant-current conditions. Usually individual stimuli (duration 0.1 ms, frequency 3 Hz) with a stimulation intensity between 0.5 and 3 mA are used. The use of a monopolar stimulation probe is also possible, but it requires for another electrode to be placed on the edge of the surgical field. However, this leads to a rather widespread electrical field and makes an exact localization of the nerve difficult.

The stimulation of the nerve results in a clearly visible wave on the monitor (Fig. 4-5). False-negative responses, meaning stimulation of an intact nerve without getting signals on the EMG monitor are not described in most studies.\(^5\) False-positive responses, meaning measurements of muscle activity after stimulation of structures other than nerves are mainly seen when using a monopolar stimulation probe due to the widespread electrical field.\(^5\) Due to these reasons our recommendation is to use a bipolar stimulation probe.

The set-up of the monitoring device can be done either by the surgeon himself or by an assistant. Since the surgeon has constant acoustic and visual control over the spontaneous and evoked muscle activity, there is no need for the presence of an assistant as additional person during the surgery.

The anatomical variability of the localization of the facial nerve in the parotid gland and its possible dislocation by the tumour make parotid gland surgery more difficult and require excellent anatomic knowledge and subtle technique of preparation.

A frequently used method for localization of the facial nerve and for its intraoperative surveillance was the observation of facial movements after accidental mechanical irritation of the nerve or after electrical stimulation with battery-operated hand-held stimulators. This requires a continuous surveillance of the patient’s face. Moreover irritations of the facial nerve during surgery frequently lead to mechanically evoked muscle activities which can be monitored by the EMG device as single or multiple discharges (bursts or trains, Fig. 4-6) but do not cause any contraction in the region of the mimic muscles and could therefore not be detected by observation of the
face. Even these subclinical mechanical irritations may cause nerve damage. Monitoring of the facial nerve informs the surgeon about these discharges and helps to avoid nerve damage.

One of the main arguments against facial nerve monitoring during routine surgery is the increased amount of time and personnel. The set-up of the monitoring device does not take more than five minutes. According to our experience, an additional assistant for observation of the neurophysiologic unit during surgery is not necessary. Even if some authors demand the continuous presence of a monitoring specialist during surgery, we think this can be easily done by the surgeon himself.\textsuperscript{3}

The argument of additional manpower is not applicable and should not be used against the routine use of neuromonitoring. According to our experience, the small amount of additional time necessary for the set-up is compensated by a shorter duration of surgery.\textsuperscript{5} Complications of neuromonitoring such as skin burns around the subcutaneously inserted needle electrodes due to malfunction of the monitoring device are fortunately extremely rare.\textsuperscript{6}

Neuromonitoring of the facial nerve is absolutely necessary in cases of extracapsular dissection of circumscribed tumours of the parotid gland. If a parotid tumour is to be removed without exposing the main stem of the facial nerve, it is indispensable to use repeated and careful stimulation around the tumour to localize and preserve small nerve branches (\textbf{Fig. 4-7}).

In our opinion there is no valid reason to renounce on safety benefits provided by the routine use of facial nerve monitoring in all cases of parotid gland surgery. Two retrospective studies have shown a better postoperative facial nerve function in patients when facial nerve monitoring was used.\textsuperscript{5, 7} Over time the surgeon gets more familiar with the technique, which leads on the one hand to a shorter set-up time and on the other hand to an easier assessment of the evoked EMG activity which can then easily be differentiated from artefacts (for instance discharges of electrostatic metallic instruments).

It goes by itself that neuromonitoring will never replace the anatomical knowledge and the surgical experience of the physician nor the sufficient exposition of the surgical field.

\textbf{EXTRA-CAPSULAR SECTION}

The fear in adopting a more conservative surgical approach to the apparent benign parotid tumour (discrete parotid lump) arises from the fact that pleomorphic adenoma has a reputation for recurrence and that this technique may lead to a recurrence. There is also the risk that a surgeon may inadvertently blunder into a malignant neoplasm masquerading as a benign lump. These two concerns have hindered the adoption of minimally invasive techniques readily accepted in other surgical disciplines.
INTRODUCTION

Facial trauma and especially parotid trauma may manifest in many clinical symptoms such as: facial nerve injuries, parotid gland and duct injuries and further involvement of the underlying anatomic structures; auditory canal and the temporomandibular joint (TMJ). It was described by Lewis et. al. that 0.21% of lacerations in the facial region resulted in a parotid duct or gland injury.¹

The mechanism of trauma is of great importance as well as the site and depth of the injury. Contusion, hematoma or laceration of the gland or duct can cause for complication to occur. Although the incidence of parotid gland and duct trauma is fairly low, all maxillofacial surgeons should be aware of such injuries and be capable of recognizing the symptoms. The immediate and late complications if not observed and treated accordingly are very difficult managed in the delayed period, these include traumatic sialocele and fistula.

Parotid gland and duct may not be the sole inflicted organ in the facial trauma, however unlike other injuries such as facial palsy or TMJ dysfunction, it is sometimes difficult to diagnose this kind of injury. Therefore attention is needed when dealing with such trauma. The exact trauma site is highly important whether it is the capsule of the gland or the duct it self, and this in turn will render the approach to be either a surgical or a conservative one.

DIAGNOSIS

The recognition and treatment of a trauma to the parotid gland or duct in time of patient admission starts with review of the injured site, the occurrence of saliva in the injured site will be indicative for laceration. Squeezing the gland in order to produce salivary flow via the Stensen's orifice and localization and visualiza-
Modern Management Preserving the Salivary Glands

Insertion of the duct by insertion of probe or cannula through the oral orifice is the second most important step. When there is a doubt regarding the duct integrity it is advised to use isotonic saline solution. Once considered as a dye solution, methylene-blue is not indicated nowadays.

Throughout the initial diagnosis, care must be taken for the facial nerve function.

Radiology assessment for parotid trauma is not indicated (excluding the use of parotid sialogram when possible), but can be used in order to exclude accompanying trauma of adjacent structures e.g.; TMJ, auditory canal.

**TREATMENT**

Two approaches are used each with its own indications.

When the parotid gland parenchyma is only contused the conservative or non-surgical approach is indicated with the use of antisialogogues, elastic bandages, this will induce hypofunction of the gland. When hematoma occurs and Stensen’s duct occlusion is possible, probing and buccinage are indicated, thus maintaining ductal competence.

However, when a laceration of the gland or duct occurs, a surgical approach is mandatory, this depends upon the exact location of the laceration; in the glandular region, over the masseter muscle or anterior to the masseter muscle.

The former injury is treated by closure of the capsule, those over the masseter are treated with a direct repair of the duct, and the latter are dealt with either repair of the duct or a new orifice formation.

When the aforementioned injuries are suspected, one should follow these suggested actions; insertion of a cannula to the Stensen’s duct (intraorally) if a deep skin laceration is present, direct visualization of the cannula as it pierces the duct is indicative of ductal laceration. If the cannula is not seen in the injury site, a saline solution is administered via the cannula, care must be taken not to over fill the gland (not more than 4 cc of fluid per gland). The presence of fluid in the injury site is indicative of ductal/glandular laceration. The amount of fluid will indicate whether the main duct is transected (large amount of fluid) or the capsule (lesser amount of fluid).

The treatment of each laceration is dealt according to its anatomical location and the ability of the surgeon to locate both ends of the duct in order to perform anastomosis.

A laceration close to the oral cavity is treated by suture and if needed a stent is inserted to maintain ductal potency.

For the measures of the stent we advise the use no more then 1 mm (3 fr) diameter and 8—10 cm in length.

Lacerations found proximally are treated by exploring the stumps (both proximal and distal) with care taken not to harm the facial nerve. The stumps are approximated, sutured with nylon (8—0, 9—0) sutures. A stent is inserted for a period of 1 month.

If direct approximation is not achieved, a graft should be considered.

In addition an active drain inserted in the injured gland will prevent saliva accumulation, thus sialocele formation is sustained.

In cases of torn duct with inability to approximate the stumps, a cannula or a stent are inserted in the proximal part of the duct and the distal part of the stent is advanced to the oral cavity. In cases of parotid capsule laceration, the capsule is inspected and sutured, a pressure dressing is applied for 48 hours, stent insertion is advised for 1 month and an active drain for a few days.

When the proximal part of the duct is not identified easily, the use of sialoendoscope is advised as follows:

A lacrimal probe is inserted in the distal part; the skin overlying the duct is approximated and the exact exit point of the probe will indicate the relative location of the proximal part of the duct. This area will now be inspected with the sialoendoscope for the exact duct location and further anastomosis will take place.
COMPLICATIONS

Sialocele and parotid fistula formation are the most common complications occurring in parotid trauma.

Both states are managed by either decreasing the salivary flow or diversion of salivary flow to the oral cavity. Gland atrophy and strictures are considered as late complications and are dealt accordingly (see relevant chapters).

Some authors report up to 58% of the patients suffers from sialocele and 30% from fistula. All received “nothing-by-mouth” treatment and were cured eventually.

A sialocele is the accumulation of saliva manifesting in a facial swelling, thus salivary secretion without the proper drainage. The diagnosis is done with aspiration, which demonstrates high amylase containing fluid.

If sialocele appears immediately, re-exploration is indicated.

Late formation of this phenomenon can be treated with repeated aspirations, continuous pressure, antiallogogues, radiotherapy, pa-
Fig 11-1. A — The facial area is divided according to Van-Sickels to 3 parts when dealing with a parotid gland and duct trauma. The horizontal line depicts the course of the Stensen's duct. B&C — A diagram of a lacerated Stensen's duct and the approximation and suturing of the stumps.
Stepping stones or stepstones are sets of stones arranged to form a simple bridge or causeway that allows a pedestrian to cross a natural watercourse, such as a river; or a water feature in a garden where water is allowed to flow between stone steps. Unlike other bridges, they have no spans. Although their origin is unknown, stepping stones, along with log bridges, are likely to have been one of the earliest forms of crossing inland bodies of water devised by humans. NHS Choices information on salivary gland stones (calculi), with links to other useful resources. These are small stones that form in salivary glands in your mouth and can block your flow of saliva. They're not usually serious and you may be able to remove them yourself. Check if you've got salivary gland stones. Most stones appear below your tongue in one of the tubes (glands) supplying saliva to your mouth. You can't always see them. Credit: Clinica claros/science photo library. Stones are white or pale and feel hard. Credit: Dr p. marazzi/science photo library. They vary in size, but most are about as big as a pea. The stones may cause: dull pain in your mouth that comes...