Facial Nerve Anatomy Revisited – A Surgeon's Perspective

Riju Ramachandran, Anoop Vasudevan Pillai

Department of General Surgery, Amrita Institute of Medical Sciences, Kochi, Kerala, India

Address for correspondence: Dr. Riju Ramachandran, Department of General Surgery, Amrita Institute of Medical Sciences, Kochi, Kerala, India.
E-mail: rijurmenon@gmail.com

ABSTRACT

Facial nerve (FN) anatomy is an enigma and its knowledge helps in safe and adequate parotidectomy without compromising the nerve. A review of the literature was done by searching the databases in PubMed, Embase, Scopus, and Google Scholar using the keywords "Parotid," "FNT," "Anatomy," "Surgery," and "Parotidectomy" and retrieving about 433 manuscripts fulfilling our requirements. FNT anatomy has been described in detail dividing the extracranial FNT under "Exit," "Trunk," "Pes Anserinus," "Divisions," "Branches," "Communications," "Relationships," and "Termination." Normal anatomy and variations including classification of the variation have been done. Knowledge of FNT anatomy helps in performing a safe parotidectomy. It is possible to preempt the course of the nerve and dissect the gland in a precise and rapid fashion, especially in surgery for a recurrence.

Key words: Parotid, facial nerve, anatomy, surgery, parotidectomy

INTRODUCTION

A surgical endeavor on the parotid salivary gland is very exciting and challenging. A simple surgery becomes so challenging due to the unique arrangement and relation of the facial nerve (FNT) with this gland. It is even the delight of the anatomist to describe the course and relationships of the FNT as it courses from the midbrain to the subcutaneous muscles of the face that it innervates. We have tried to revisit the anatomy of the extracranial course of the FNT, a complex anatomical problem every surgeon has to deal with while performing a superficial or total parotidectomy. Our department is routinely involved in the treatment of patients with diseases of the salivary glands. The unit headed by the primary author has experience performing parotid surgery for about 20 years having done over 200 parotid procedures. The institution also has an exclusive head-and-neck surgery department which is a large volume center for head-and-neck malignancies including parotid. However, data from the head-and-neck surgery department was not included in the review. Data on the patients that underwent parotidectomy are recorded in the hospital information system. Details of the anatomy of the nerve, variations, type of procedure, indication, and such other information are routinely recorded in our hospital database. These were retrieved, reviewed, and detailed notes prepared

in the making of this manuscript. Photographs of the anatomy of the FNT and dissection for the parotid surgery are routinely taken and maintained in the department. These pictures were reviewed and a few pictures were included in this manuscript.

The literature review for the article was started in 2018. The first author was invited as faculty for giving a lecture on FNT dissection during parotidectomy at the National Conference of Rural Surgeons of India in October 2018. The initial idea for this document came during the preparation for delivering the lecture. Based on the discussion and inputs from the conference we decided to carry the work forward. Work was discontinued briefly during the lockdown for COVID in 2020. The review was restarted in October 2021. Medical literature was reviewed by accessing the electronic databases of PubMed, EMBASE, Scopus, and Google Scholar using key words "Parotid,""FNT," "Anatomy," "Surgery," and "Parotidectomy." Literature available from the early 1900s to the present day was studied and noted. Details were also taken from the standard textbooks on pure and surgical anatomy and major books on surgical procedures.

For the purpose of the review, the FNT was divided into "Exit," "Trunk," "Pes Anserinus," "Divisions," "Branches,"

"Communications," "relationships," and "termination." Literature regarding each of these segments was separately obtained. Around 433 manuscripts and three textbooks were reviewed. Many of these papers presented the general FNT anatomy as a small part of the data. These were omitted. An initial skeleton of the document was prepared. Both authors then separately went through the retrieved literature search to get additional points to enhance the depth of information on FNT. Only documents having specific mention of variations in FNT anatomy, methods to identify the trunk or the nerve monitoring techniques mentioning the anatomy were included in the study. After sifting through the data, 42 papers were included for describing the various parts of the FNT anatomy. Thirteen of these papers had data which had been duplicated in other papers and were further excluded from the study. References of the selected studies were further searched for important relevant studies. Google search engine was also utilized to obtain related studies.

The matter was discussed in the department with surgeons from other units, for additional input and individual experiences of fellow surgeons in the department. This article will describe the extracranial course of the FNT and its anatomical variations which can confuse a surgeon. A knowledge of this variation will help in modifying surgical techniques to overcome the same.

INTRACRANIAL FACIAL NERVE ANATOMY

We shall briefly describe the intracranial course in the following paragraphs before the extracranial course for the sake of anatomical completion.

Nucleii

FNT takes its origin from four nuclei in the lower pons. These are

- Motor nucleus or branchiomotor
- Superior salivatory nucleus or parasympathetic
- Lacrimatory nucleus is also parasympathetic.
- Nucleus of the tractus solitarius which is gustatory and also receives afferent fibers from the glands (sensory).

Together they help give five functions ascribed to the nerve namely.
1. *Special visceral* or *branchial efferent* – Motor function to muscles responsible for facial expression and for the elevation of the hyoid bone
2. *General visceral efferent* or parasympathetic which is secretomotor to the submandibular, sublingual salivary glands, the lacrimal gland, and glands of the upper aerodigestive tract
3. *General visceral afferent* carrying afferent impulses back from all these glands
4. *Special visceral afferent* fibers carrying taste sensations from the palate and from the anterior two-thirds of the tongue except from vallate papillae through the chorda tympani
5. *General somatic afferent* - *Sensory* fibers innervating a part of the skin of the ear.

The nerve runs along with the eight cranial nerves and goes forward and laterally to enter the internal auditory meatus. The nerve has two parts at this region a larger motor and a smaller sensory root – also called nervus intermedius. At the meatus, the nerves lie in a grove of the 8th nerve accompanied by labyrinthine vessels. At the bottom of the meatus, the two nerves fuse.

Within the canal, the nerve has three parts defined by two bends – First part runs laterally and bends to run backward in relation to the medial wall of the middle ear. At this point, it is above the promontory. There is an acute bend between the two parts called the genu. It forms the region of the geniculate ganglion of the nerve. There is now a smooth second bend and the nerve continues forward in the third part vertically downward behind the promontory to exit the cranium at the stylomastoid foramen (SMF).

Extracranial facial nerve

The FNT exits the cranium through the SMF and has a short course of about 1 cm outside the parotid before it enters the gland along its posterolateral surface [Figures 1 and 2a]. Ghosh *et al.* have described morphological variants of the SMF such as triangular, rectangular, serrated, round, oval, bean-shaped, and irregular. These variants can be
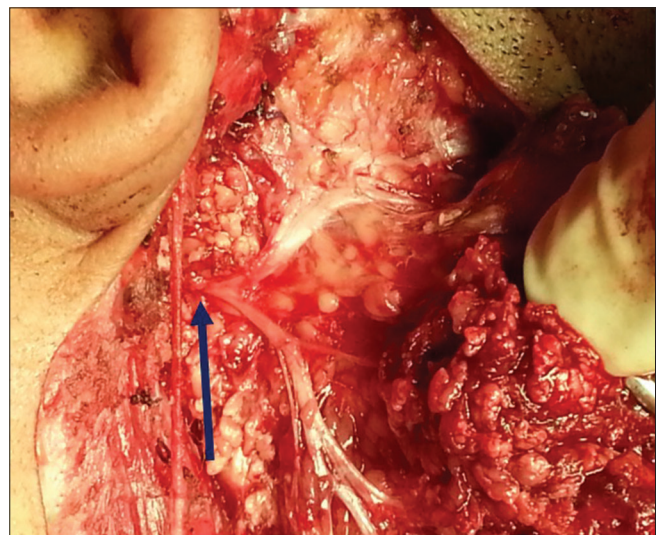

Figure 1: Entry point of facial nerve from the stylomastoid foramen

potential risk factors causing injury to FNT as it exits the skull base.[1]

The biggest sigh of relief for the surgeon dissecting a difficult parotid is to see this 1 cm trunk of the FN as it exits the SMF. Identification of this trunk of the FN is a cause for intrigue to surgeons while performing parotidectomy for large tumors. A tumor in the deep lobe may push the nerve laterally making it more superficial and prone to injury at dissection, while a large tumor in the superficial lobe may push the nerve medially and deep and makes identification of the trunk difficult [Figure 2b]. A few useful tips to consider in identifying the trunk are given below.

Approaches to trunk identification in difficult situations.
*   The tragal pointer is a triangular extension of cartilage which is seen inferiorly off the tragus, When dissected it suggests the location of the FNT in the direction of its inferoanterior point, usually about a centimeter below and medial to it
*   The styloid process can be exposed bluntly from a superior approach, and the nerve is found inferolateral to it
*   The tympanomastoid suture (TMS) line can be followed to the SMF. FNT can be identified a few millimeters deep to the outer edge of the TMS which can be felt as a hard ridge under the cartilaginous part of the external auditory meatus
*   The posterior belly of the digastric muscle crosses the sternocleidomastoid muscle approximately 1 cm inferior and 1 cm superficial to the location of the nerve. It is highly useful as a marker of the depth of the FNT [Figure 3a]
*   Any peripheral branch, including the branch to the digastric muscle, can be followed back to the main trunk, which is then dissected in the usual fashion. This is called the retrograde dissection
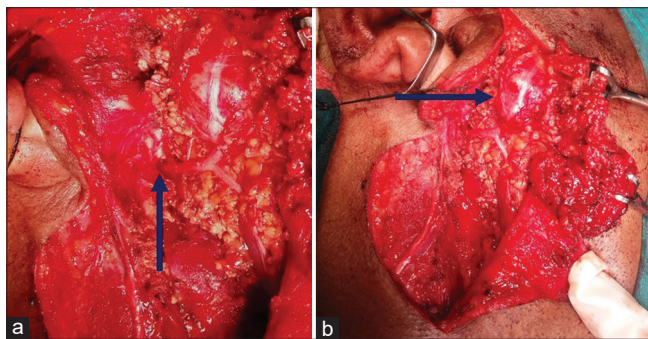*   The mastoid can be drilled to allow identification of the FNT in settings of severely abnormal anatomy, complicated revision surgery, or large tumors abutting the SMF
*   The use of nerve stimulators has been described since the 70s. It becomes very useful in recurrence and also for inexperienced surgeons[2]
*   Photographs of the nerve anatomy taken at first surgery are also useful when planning surgery for recurrent disease. Dense strands of adhesion may sometimes mimic nerves [Table 1].

There is usually a branch from the occipital artery that lies lateral to the FNT near its exit from SMF. This can often be a source of irritation when it bleeds during the dissection before identifying the nerve trunk. Another landmark is the stylomastoid artery, a branch of the posterior auricular artery. Sometimes, it may originate from the occipital artery or the external carotid artery. A large caliber stylomastoid artery can mask the main trunk of the FNT in some cases.[3-5]

Tragal pointer being a mobile, cartilaginous, and blunt with an irregular tip can be confusing at times to describe the anatomical landmark.

Borle's triangle

A recent paper by Borle *et al*. has described a triangle in the region of the parotid which enables the identification of the FNT trunk.[6] They outlined the triangle with the help of three constant landmarks which do not get involved due to parotid diseases. The three landmarks that help in the identification of this triangle are the inferior tip of the mastoid process, posterior border of the ramus of the mandible, and the superior border of the posterior belly of the digastric muscle.
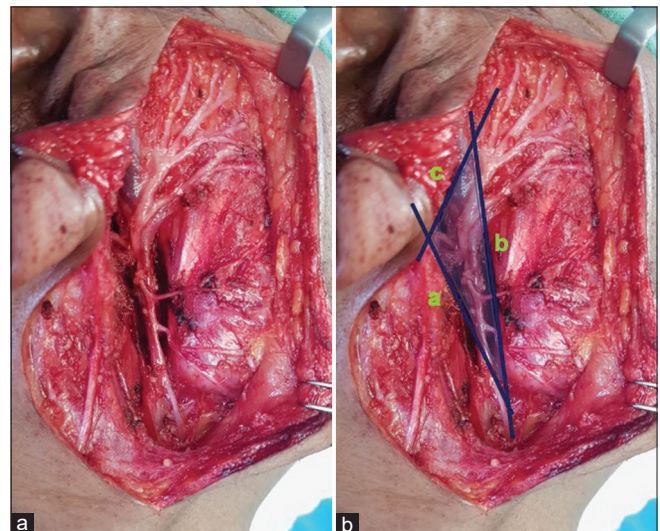

Figure 2: (a) Entry point of facial nerve from stylomastoid foramen. (b) Facial nerve pushed laterally by tumor

Figure 3: (a and b) Borle's triangle and its boundaries

Borders of the triangle

a. Line drawn along the superior border of the posterior belly of digastric from the tip of mastoid process
b. Line drawn along the posterior border of the ramus of the mandible
c. Line running anteriorly from the tip of mastoid process and joining the second line [Figure 3b].

According to Borle et al., the FNT trunk is usually found around 9 mm to 15mm from the angle between line "a" and line "c" with a mean distance of around 12.18 ± 2mm.

Pes anserinus

The parotid plexus or pes anserinus ("goose's foot") is the branch point of the extratemporal FNT after it leaves the SMF. This division usually takes place within the parotid gland. Occasionally, it can be outside the gland. The FNT now divided into cervicofacial and temporofacial divisions [Figure 4]. Rarely, the pes anserinus is missing and all branches arise from the main trunk itself.[7,8]

Fasciovenous plane of patey

Within the gland, the FNT and its branches and retromandibular vein (RV) lie in one plane. In this plane, the gland can be split sagitally into two parts, superficial and deep parts without injuring the nerve. Rarely, the nerve can sometimes be completely outside the parotid gland. Sometimes, it can lie deep to the RV.[9]

RV lies medial to the FN temporofacial and cervicofacial divisions in 90%. The RV course is medial to the temporofacial and lateral to the cervicofacial divisions in 10% [Figure 5].[10] The literature describes the classical position of RV to be medial to the temporofacial and cervicofacial divisions of the FN.[10] RV found lateral to FN is the second-most commonly described variation [Table 2]. Based on this relationship of the FN to the RV, Touré et al. proposed a classification which is given in the table below [Table 3].[11]

Other rare variations seen at this point are[15-17]

• Inferior division of FN was deep into the RV
• FN and its branches were found encircled by venous rings[18]
• FN forked between the MV and its divisions.

Table 1: Various studies with distance from various landmarks

Clinical studies	Distance from PBDM	Distance from tragal pointer	Distance from TMS
Rea et al.[25]	5.5±2.1 mm	6.9±1.8 mm	2.5±0.4 mm
Pather and Osman[26]	9.7-24.3 mm	24.3-49.2 mm	4.9–18.6 mm
Witt et al.[27]	12.4 mm (cad)	-	1.8 mm (cad)
	10.7 mm (live)	-	2.0 mm (live)
Saha et al.[28]	6-9.5 mm (cad)	14-21 mm (cad)	2.5-4.5 mm (cad)
	6-11.5 mm (live)	13.5-19 mm (live)	2-6 mm (live)
Borle et al.[6]	-	12.18±2 mm	-
Ji et al.[29]	8.79±3.99 mm	13.6±11.0 mm	3.79±2.92 mm

PBDM: Posterior belly of digastric muscle, TMS: Tympanomastoid suture

Table 2: Variations in different clinical studies

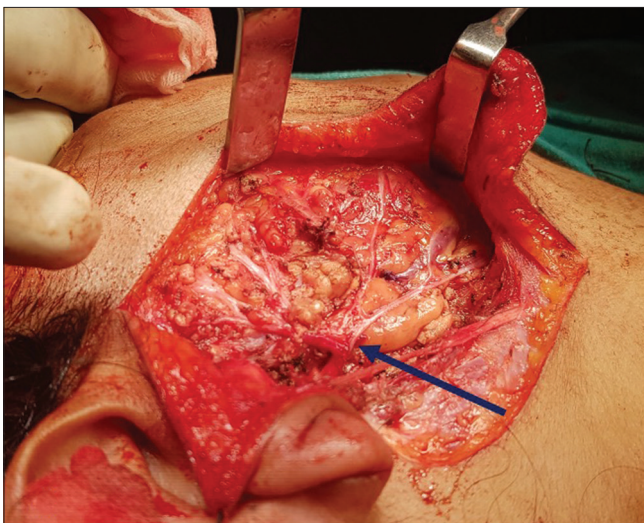| Clinical studies	Type I (%)	Type II (%)
Touré and Vacher[11]	65.2	13
Dingman and Grabb[12]	98	2
Kim et al.[13]	83	17
Mahore et al.[14]	87.5	Other variations (12.5)

Figure 4: Pes anserinus

Figure 5: Retromandibular vein lateral to the divisions of facial nerve (Type IId)

Since these variations could not be accounted for in the previous classifications, Piagkou *et al.* in 2013 proposed an updated classification based on the relationship of FN to RV.[10] In this classification, Type I includes the classically described deep position of the RV to FN, Type II includes superficial position of the RV to FN. In Type III, RV forms a venous ring around the FN [Table 4].

In rare cases, the FNT and its branches crossover the superficial temporal vein and maxillary vein either in front or behind these veins. This relationship is shown in Type IV. The table shows the classification that has been adapted from a similar illustration by Piagkou *et al.* [Figures 5 and 6].[10]

The classical description of FNT dividing into its five terminal branches happens as a rarity and is seen in only one-third of the patients undergoing parotidectomy.[19] The five branches described are temporal, zygomatic, buccal, marginal mandibular, and cervical.

For a surgical dissection, two nerves are critical

- The zygomatic branches of the FNT (malar branches) run across the zygomatic bone to the lateral angle of the orbit
- The marginal mandibular branch that lies along the body of the mandible (80%) or within 1–2 cm below (20%). The marginal mandibular branch lies deep to the platysma throughout much of its course. It becomes more superficial approximately 2 cm lateral to the corner of the mouth and ends on the undersurface of the muscles
- The temporal branch of the FNT exits the parotid gland and runs within the SMAS over the zygomatic arch into the temple region.

Table 3: Classification of facial nerve in relation to retromandibular vein according to Touré and Vacher[11]

Types	Variations
Type I	RV medial to FN (commonest) (65%)
Type II	RV lateral to FN (35%) [Figure 5]
Type III	RV found lateral to the FN main trunk
Type IV	RV found lateral to the cervicofacial division
Type V	RV found lateral to the temporofacial division
Type VI	RV found lateral to some of the cervicofacial FN branches

FN: Facial nerve, RV: Retromandibular vein

Table 4: Classification of facial nerve in relation to retromandibular vein according to Piagkou *et al.*[10]

Types	A	B	C	D	E	F
I						
II						
III						
IV						

Figure 6: (a and b) Retromandibular vein medial to upper division of facial nerve (Type IIb) (Right and Left side)
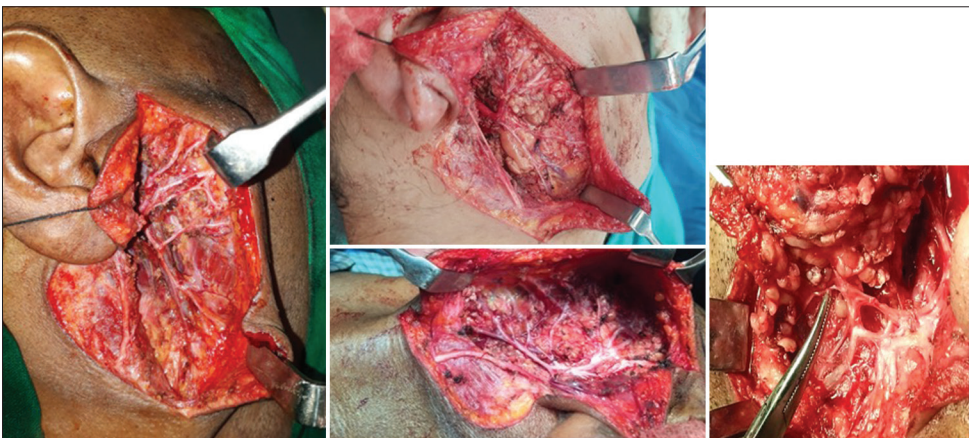

Figure 7: Intercommunications of facial nerve divisions

Table 5: The classification based on branching patterns and intercommunications between facial nerve	
Types	Variations
Type I	No anastomosis between the temporofacial division and cervicofacial division
Type II	Anastomosis only between the branches of the temporofacial division
Type III	Single anastomosis between the branches of the temporofacial and cervicofacial divisions
Type IV	Combination of Type II and III
Type V	Double anastomosis between the branches of the temporofacial and cervicofacial divisions
Type VI	Complex numerous anastomoses between the two divisions, where the buccal branch receives many fibers from the mandibular branch and the cervicofacial division

Classification of branching patterns of FNT was first described by Davis *et al*. into six types, namely Type I – VI [Figure 7 and Table 5].[20] Later in 1987, Katz and Catalano came up with a different classification which included nine types, namely Type IA, IB, II, IIIA, IIIB, IIIC, IVA, IVB, and V.[21]

Kopuz *et al*. added three additional dual trunk types, namely Type VA, VB, and VC. The branching pattern of the FNT is variable and has been classified into six types and are.[8]

Interconnections between the zygomatic and buccal branches are noted in over 70% of cases, whereas interconnections between the temporal or marginal mandibular branches to other FNT branches occur in less than 15% of cases.[22] The buccal branch of the FNT has a close relationship with the parotid duct for over 2.5 cm after it emerges from the parotid gland; it normally lies inferior to the duct.[23] This branch is very variable and based on its relationship with the parotid is classified into four types:[24]

- Type I: A single buccal branch of the FNT at the point of emergence from the parotid gland and inferior to the parotid duct
- Type II: A single buccal branch of the FNT at the point of emergence from the parotid gland and superior to the parotid duct
- Type III: Buccal and other branches of the FNT form a plexus
- Type IV: Two branches of the buccal branch; one superior and one inferior to the duct at the point of emergence from the parotid gland.

However, the parotid duct accompanies the upper buccal branch inferiorly in most cases. Once, the nerve exits the gland they become more superficial and innervates the muscles of facial expression. The FNT innervates 14 of the 17 paired muscle groups of the face on their deep side. Buccinator, levator anguli oris and mentalis muscles are innervated on their superficial or lateral edges.

It is seen that the nerve is at a deeper plane at its exit from the SMF and becomes superficial as it comes to the terminal end.

CONCLUSION

Identifying and preserving the nerve gives the patient a cosmetic and esthetically pleasing result, but in an inexperienced hand, the surgery may be a cosmetic nightmare for the patient, the rest of their life. Knowledge of FNT anatomy helps in performing a safe parotidectomy. It is possible to preempt the course of the nerve and dissect the gland in a precise and rapid fashion, especially in surgery for a recurrence.

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