



Anatomical assessment of the digastric branch of the facial nerve as a landmark to localize the extratemporal facial nerve trunk

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Abstract

Purpose Localization of the facial nerve trunk (FNT) [i.e., the portion of the facial nerve between the stylomastoid foramen (SMF) and pes anserinus] may be required during various surgical interventions such as parotidectomy and hypoglossal-facial anastomosis. Several landmarks have been proposed for efficient identification of the FNT. We sought to assess the anatomical features of the digastric branch of the facial nerve (DBFN) and its potential as a landmark to identify FNT.

Methods Fifteen sides of eight cadaveric heads were dissected to find the DBFN. Anatomic features of DBFN including its point of origin relative to SMF, length, and important relationships, as well as the distance between the insertion point on the digastric muscle and mastoid tip were recorded.

Results DBFN was found in all specimens originating from the FNT outside the SMF with an average length (\pm standard deviation) of 15.4 ± 3.4 mm. In all specimens, the DBFN inserted on the superomedial aspect of the posterior belly of the digastric muscle (PBD). In 8/15 specimens, DBFN was accompanied by the stylomastoid artery on its anteromedial side. Average distance (\pm standard deviation) between the mastoid tip and the nerve insertion point on PBD was 13.6 ± 2.0 mm (range 10–17).

Conclusions The DBFN is a reliable landmark for identifying the FNT. It could be consistently identified within 15–20 mm of the mastoid tip on the superomedial aspect of the PBD. The DBFN may be used as a supplementary landmark for efficient localization of the FNT.

Level of evidence Not applicable (anatomic study).

Keywords Digastric Muscle · Hypoglossal-facial anastomosis · Parotidectomy

Introduction

Exposure of the extratemporal portion of the facial nerve may be required in various surgical procedures in the vicinity of the parotid gland such as exposure of glomus jugulare tumors, parotidectomy and hypoglossal-facial anastomosis

[19, 33]. Therefore, efficient identification of the facial nerve using reliable landmarks is of paramount importance to avoid complications.

There are two general techniques to identify the extratemporal facial nerve: retrograde and anterograde. In the anterograde technique, the facial nerve trunk (FNT) (i.e., the segment of the facial nerve between the stylomastoid foramen [SMF] and the bifurcation of the nerve inside the parotid gland) is localized. Whereas in the retrograde technique, a distal branch of the nerve (such as the buccal branch) is found and traced back to the main FNT [16, 23, 30], with or without using the guide of superficial landmarks such as the retromandibular or superficial temporal veins [15].

The anterograde technique is generally preferred for parotid gland surgery and hypoglossal facial-anastomosis, as the FNT has a relatively consistent course and more predictable anatomic relationships compared to its terminal branches [7]. Various landmarks have been suggested and

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studied to efficiently localize the FNT, including the tragal pointer [3, 7, 22, 25, 35], tympanomastoid fissure (TMF) [2, 5, 7, 22, 25, 28], posterior belly of the digastric (PBD) [7, 12, 22, 25, 26], mastoid process [9, 11], external auditory meatus [12, 22, 25], styloid process [5, 22, 26, 33], and the transverse process of atlas [11, 22]. None of these landmarks is perfect, although the bony landmarks are said to be more reliable (Table 1) [6, 7]. However, all these *quantitative* landmarks—based on their distance to FNT—suffer from a major drawback: they could be unreliable in the individual patient whose anatomy and measurements deviate from previously published measured distances [2, 22, 33]. For this reason, the use of qualitative landmarks is helpful, especially in cases of distorted anatomy due to the presence of a pathology. Examples of these qualitative landmarks include the stylomastoid artery (SMA) [20, 34], the posterior auricular nerve (PAN) [32], posterior auricular artery (PAA) [18], and the digastric branch of the facial nerve (DBFN) [4, 14, 24] (Fig. 1). Following these landmarks leads to the FNT and they are relatively independent of measurements, because they have a direct anatomic relationship with the FNT.

The DBFN is a small branch usually originating from the extratemporal FNT after the PAN [1, 10, 31, 36]. Despite

mentioning the use of DBFN to find the FNT in some previous works, no study has assessed the microsurgical anatomy of this structure as a landmark to localize the FNT [4, 14, 24]. In the present study, we assessed the anatomy of the DBFN and the reliability of its use as a qualitative landmark to localize the FNT.

Materials and methods

Fifteen sides of 8 cadaveric heads (prepared for dissection using a customized alcohol-based embalming formula) were examined. Procurement of all cadaveric specimens was according to the standards of “American Association of Tissue Banking” and “The Uniform Anatomical Gift Act”. The heads did not have any intracranial or cervicofacial pathology. Arteries and veins were perfused with red- and blue-colored silicone, respectively. A straight incision was started on the mastoid region and continued inferiorly along the anterior border of the sternocleidomastoid (SCM). After incising the platysma and superficial musculoaponeurotic system (SMAS), tail of the parotid gland was separated from the anterior border of the SCM. The deep cervical fascia was

Table 1 Common landmarks to localize the FNT during surgery. Adapted from Ji et al. [13]

Landmark	Description	Value (mm) ^a	Disadvantages
PBD	Closest distance between the PBD and the FNT	8.8 ± 4.0	Retractability and flexibility of the PBD causes the variability of this landmark to be relatively high
Tragal pointer	Part of the tragal cartilage pointing towards the direction of the facial nerve	13.6 ± 11.0	The direction of the tragal pointer is not always deciphered easily High variability
Tympanomastoid fissure	The V-shaped bony fissure between the mastoid and tympanic parts of the temporal bone leads to the FNT	3.8 ± 2.9	Finding the TMF may be difficult because it is buried under the thick SCM tendon In most patients, the TMF is more a palpable landmark rather than a visualized one [28] Seeking to find the TMF increases surgical complexity
Mastoid process	Closest distance between the tip of the mastoid process and the FNT	10.5 ± 1.4	No specific procedural technique is described to find the FNT starting from mastoid process High variability
C1 transverse process	Closest distance between the tip of the transverse process of the first cervical vertebral and the FNT	15.0 ± 1.7	No specific procedural technique is described to find the FNT starting from tip of C1 transverse process C1 transverse process tip is not always exposed in the surgical field
EAM	Closest distance between the external auditory meatus and the FNT	11.8 ± 1.4	No specific procedural technique is described to find the FNT starting from EAM
Styloid process	Closest distance between the tip of the mastoid process and the FNT	9.8 ± 0	The styloid process is located deep to the FNT and the FNT may be found/injured before exposing the styloid process Abnormally shaped (or absent) styloid process or calcification of stylohyoid tendon may render this landmark unusable [2]

EAM external auditory meatus, FNT facial nerve trunk, PBD posterior belly of digastric muscle, TMF tympanomastoid fissure

^aValues are presented as mean ± standard deviation.

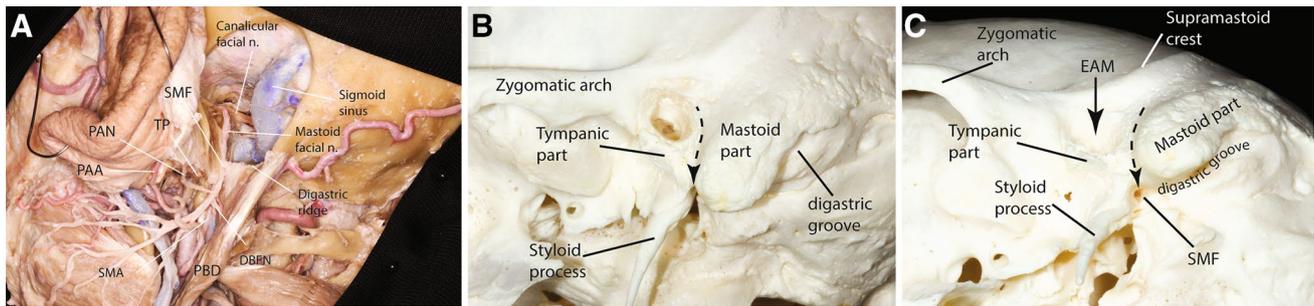


Fig. 1 Landmarks to identify the facial nerve trunk. **a** A left-sided dissection of a cadaveric head exposing the facial nerve from its canalicular segment to its distal branches. Note different landmarks such as the PBD, TP, SMA, PAA, PAN, and DBFN. **b**, **c** Dry skull photos showing the landmark of tympanomastoid fissure (dashed curved arrow) leading to the SMF. **b** Lateral view. **c** Inferior oblique

view. *DBFN* digastric branch of the facial nerve, *n* nerve, *PAA* posterior auricular artery, *PAN* posterior auricular nerve, *SMA* stylomastoid artery, *SMF* stylomastoid foramen, *TP* tragal pointer (Used with permission from Barrow Neurological Institute, Phoenix, Arizona, USA.)

then incised anterior to the SCM to localize the PBD. Subperiosteal dissection was then performed to partially separate the insertion of the SCM onto the tip of the mastoid process and expose the mastoid tip. Dissection was continued on the superomedial aspect of the PBD to localize the point of insertion of the DBFN on the PBD. Next, the DBFN was followed proximally to localize the FNT. Important relationships between the DBFN and adjacent structures were recorded. Distance between the insertion point of the DBFN on the PBD was measured from mastoid tip (Figs. 2, 3). In addition, the length of the DBFN was measured from its origin to muscle insertion. Next, a limited mastoidectomy was performed using a high-speed drill (Midas Rex, Medtronic, Minneapolis, MN), to unroof the SMF. The exact location of the SMF was determined by identification of the extraforaminal fat tissue (Fig. 3). The relationship between origin of the DBFN and the SMF was determined as pre-foraminal (i.e., intratemporal), foraminal (i.e., within the boundaries of SMF), or post-foraminal (i.e., extratemporal). Measurements were performed with a hand-held Vernier caliper with 0.1 resolution.

Results

In all specimens, the DBFN was found to originate from the extraforaminal portion of the facial nerve ($n = 15$); i.e., just outside the SMF. Average length of the DBFN was 15.4 ± 3.4 mm (range 11–22) with a 95% confidence interval of 13.7–17.1 mm. The insertion point of the DBFN onto the PBD was located on the superomedial aspect of the muscle with an average distance of 13.6 ± 2.0 mm from the tip of the mastoid process (range 10–17) with a 95% confidence interval of 12.6–14.6 mm. The insertion point was apparent as a thickened area of the investing fascia of PBD (Fig. 3). In 8/15 specimens, the DBFN was accompanied by the SMA

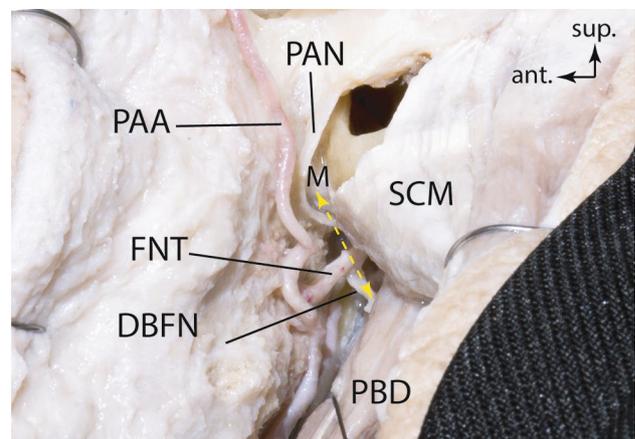


Fig. 2 Exposure of DBFN. After a linear oblique incision extending inferiorly from the mastoid area, the SCM is retracted posteriorly and the PBD is exposed. The PAA is found running in the subcutaneous tissue in the retroauricular region. The PAN is usually found at the anterior aspect of the mastoid process in the subcutaneous tissue and it usually accompanies the PAA. Please note the crossing between the PAA and FNT. The insertion point of the DBFN into the PBD is found at the superomedial aspect of the PBD near the tip of the mastoid process (*M*). The distance between (*M*) and the insertion of DBFN into PBD were measured (dashed double-headed yellow line) as well as the length of the DBFN. Please note that limited mastoidectomy has been performed in this specimen. *DBFN* digastric branch of facial nerve, *FNT* facial nerve trunk, *M* tip of the mastoid process, *PAA* posterior auricular artery, *PAN* posterior auricular nerve, *PBD* posterior belly of digastric muscle, *SCM* sternocleidomastoid. (Used with permission from Barrow Neurological Institute, Phoenix, Arizona, USA.)

which ran anterior and medial to the DBFN to enter the SMF (Fig. 3a). In the majority of specimens (14/15), the DBFN ramified into 2–4 terminal branches that inserted onto the muscle. The SMA originated from PAA in 10/15 and from the occipital artery in 5/15 specimens. The SMA was always anterior and medial to the DBFN. As the PBD covered the

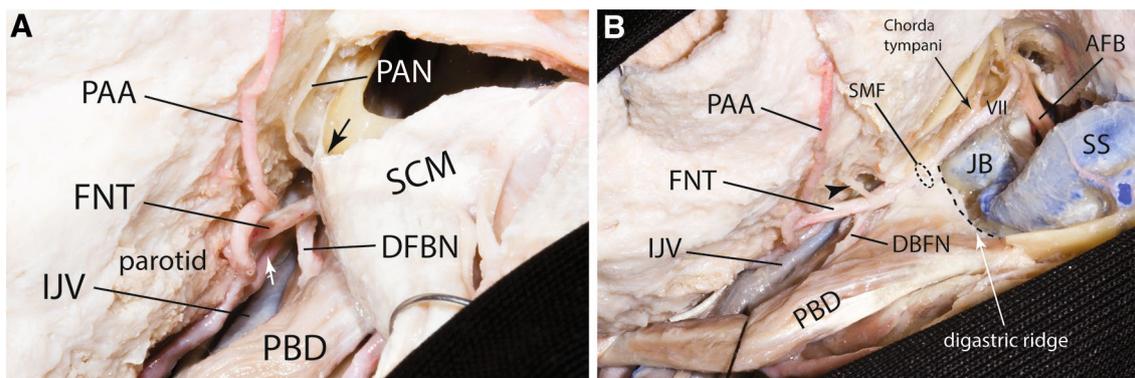


Fig. 3 **a** Oblique view of the left mastoid region with exposure of PAA, PAN, and DBFN. DBFN originates from the FNT distal to the stylomastoid foramen. Important medial relationships of the DBFN include the IJV and the stylomastoid artery (white arrow). Please note that limited mastoidectomy has been performed in this specimen. Mastoid tip is marked by black arrow. **b** Mastoidectomy and trans-labyrinthine approaches have been completed and full course of the facial nerve is exposed from the cerebellopontine angle to the parotid

region. PAN (black arrowhead) and DBFN arise from the extratemporal portion of the facial nerve. *AFB* acousticofacial bundle, *DBFN* digastric branch of facial nerve, *FNT* facial nerve trunk, *IJV* internal jugular vein, *JB* jugular bulb, *PAA* posterior auricular artery, *PAN* posterior auricular nerve, *PBD* posterior belly of digastric muscle, *SCM* sternocleidomastoid, *SMF* stylomastoid foramen, *SS* sigmoid sinus. (Used with permission from Barrow Neurological Institute, Phoenix, Arizona, USA.)

anterolateral aspect of the carotid sheath, DBFN coursed anteromedial to the carotid sheath (specifically the internal jugular vein) to reach the FNT (Fig. 3).

Discussion

The DBFN was invariably found on the superomedial aspect of the PBD (within 15–20 mm of mastoid tip) and consistently led to the extraforaminal portion of the facial nerve (i.e., FNT). These findings show that the DBFN is a reliable landmark to localize the FNT.

Landmarks for FNT localization

Quantitative landmarks

Several landmarks have been proposed to localize the FNT during surgery [2, 3, 5, 7, 9, 11, 12, 22, 25, 26, 33, 35]. The two most commonly used and reliable landmarks are the TMF and the PBD (Fig. 1) [5, 7, 17, 22, 26, 27]. The FNT could be generally found within 3.8 ± 2.9 mm of the medial end of the TMF [2, 7, 33], and within 8.8 ± 4.0 mm of the PBD [12, 13]. However, the variability of the measured distance between these landmarks and the FNT is not low [13]. For example, de Ru et al. [7] report the distance between the TMF and the FNT to be 2–3 mm, but Pather and Osman [22] report a range of 4.9–18.6 mm. Furthermore, some authors state that exposing the TMF adds to the complexity of the procedure because it requires subperiosteal dissection around the external auditory meatus [13, 21]. Additionally,

finding the TMF is not always easy, as it is covered by the thick SCM tendon [21, 22, 27].

On the other hand, the PBD has the drawback of flexibility and being subject to retraction, leading to imprecision and unreliability of the reported distances between the PBD and the FNT. Furthermore, the observed variability in the reported distances between the FNT and the above-mentioned or other landmarks (e.g., tragal pointer, mastoid process, etc.) may stem from inconsistent definition of the exact location of these reference points, and/or natural differences between different populations and sexes [22, 25]. Therefore, the use of qualitative landmarks is a helpful adjunct to the quantitative measures for localization of the FNT.

Qualitative landmarks

The stylomastoid and posterior auricular arteries The SMA is usually a branch of the PAA (or less frequently from the OA or external carotid artery) that accompanies the proximal FNT and enters the SMF to feed the mastoid segment of the facial nerve (Fig. 3a) [8, 20]. It has been suggested as a landmark to localize the FNT [34]. However, the artery may not be always identifiable [29, 34]. Additionally, it has an inconstant origin and course relative to the FNT [20, 29]. Furthermore, the SMA is very close to the FNT and identifying the artery could be as difficult as finding the FNT. In fact, no clear stepwise technique has been described to efficiently expose this small artery. Furthermore, the artery usually runs medial to the nerve and the FNT may be exposed before the SMA [20]. Overall, the SMA may not be a reliable landmark for locating the FNT.

Liu et al. studied the reliability of the PAA to locate the extratemporal facial nerve trunk [18]. They found that the PAA originated from the external carotid artery and crossed the FNT in 10/10 specimens just outside the SMF. While the relationship between PAA and FNT seems to be constant and may be useful as an adjunct landmark for FNT identification, locating the PAA in the subcutaneous plane between the auricle and the mastoid process (as described by Liu et al.) may be challenging (Fig. 3). The reason is that PAA is a small artery and is located inside the tight subcutaneous space between the auricle and the mastoid process. Furthermore, during neurosurgical procedures in the region (e.g., retrosigmoid craniotomy), the skin in the mastoid region is usually reflected as a whole flap using the subperiosteal dissection technique at the beginning of surgery. In this situation, finding the PAA may be very difficult inside the musculocutaneous flap. According to Liu et al., the average distance between the mastoid tip and the PAA was 12.9 ± 2.9 mm [18]. However, the study failed to delineate reliable landmarks and a stepwise surgical dissection plan to pinpoint the PAA using the measurements provided. Importantly, the PAA may arise from OA in 10–15% of cases and Liu et al. did not study the reliability of PAA as a landmark for FNT when this variation is present [18].

Posterior auricular nerve The PAN is the first extratemporal branch of the facial nerve (Figs. 1, 2, 3) [10, 32]. It usually originates from the FNT within 5 mm of the SMF and innervates the rudimentary posterior and superior auricular muscles [29, 32]. Keefe et al. suggested retrograde dissection of the PAN to find the FNT [16]. In this proposed technique, the parotid is dissected off the auricular cartilage, mastoid and SCM. Next, the PAN is found in the depths of the areolar tissue on the mastoid process [16]. Similar to the situation with the PAA, finding the PAN (which usually runs with the PAA [18]) in the subcutaneous tissue is difficult. Furthermore, the PAN may not always run on the lateral aspect of the mastoid process. According to Smith et al., the PAN runs deep to the mastoid process to reach the retroauricular region in 63% of cases [32]. Therefore, the PAN may not be an ideal landmark to localize the FNT.

Digastric branch of facial nerve The DBFN is usually the second extratemporal branch of the FNT (after the PAN), arising from the FNT 3.6 ± 0.8 mm distal to the SMF (Fig. 3) [29]. We found that it always originates from the extratemporal portion of the facial nerve. Our results show it could be consistently found on the superomedial aspect of the PBD within 15–20 mm of the mastoid tip. Retrograde dissection of this branch (sometimes multiple branches insert onto the PBD) for approximately 15 mm leads to the FNT. The main advantages of using this branch for finding FNT is its consistent location and short course.

In addition, exposing the PBD is a natural step in exposing the FNT, and does not require any additional surgical maneuver. In a case report, Kanatas et al. reported the use of the DBFN to localize the extratemporal FNT [14]. In their proposed technique (similar to our technique), the tail of the parotid is separated from anterior border of the SCM. Next, the PBD is exposed deep and medial to the SCM and the DBFN is found on the superomedial aspect of the PBD near the tip of the mastoid process [14]. Using a nerve stimulator may facilitate localizing the DBFN [14]. It should be noted that the DBFN is a tiny branch and may be injured or missed during dissection. This can be considered the most prominent disadvantage of this landmark when it is used as a solitary guide to localize the FNT. This branch may even become smaller in longstanding facial nerve palsy. Additionally, when a parotid tumor is being resected, the DBFN may be involved in the tumor and therefore loses its applicability as a guide to the FNT. However, with meticulous surgical technique, in cases with normal anatomy, the DBFN may be effectively used as a standalone or supplementary landmark to localize the FNT anatomy (such as hypoglossal-facial anastomosis). Indeed, establishing the DBFN as a practical landmark requires further clinical experience although it has been previously reported by several authors [4, 14, 24].

Conclusion

We have assessed the anatomical features of the DBFN as a landmark to localize the extratemporal portion of the facial nerve. The DBFN is a consistent and reliable landmark that could be used as a standalone or in combination with other landmarks to increase the efficiency of localization of the FNT. Further clinical use of this landmark helps to delineate its practicality during surgery of the facial nerve.

Author contributions ATM: Project Development, Data Collection, Data Analysis, Manuscript Writing. LBM: Data Collection, Data Analysis, Critically Revising the Article. MTL: Critically Revising the Article. MCP: Project Development, Critically Revising the Article, Study Supervision, Technical and Administrative Support.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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