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FULL PAPER

An anatomical study of main body and branches of facial nerve

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The aim of this study was to describe the anatomical characteristics of the main body and the branches of the facial nerve. A descriptive study was conducted on 30 half-head cadavers in Anatomy Department of The Pham Ngoc Thach University of Medicine from October 2022 to April 2023. 30 half–head cadavers, 10 skull men, the mean age is 70.100% of the sample had only one common exit from the foramen stylomastoid. The average depth from the skin surface to the emergence point of the facial nerve on the right side after the stylomastoid foramen was 28.9 mm, while on the left side, it was 25.1 mm. Main body length 14.1 mm average facial nerve. The main body diameter was 2.5 mm on average. The average number of branches of the main body was 2.1 on both sides sector, the main body split ratio 2 sector accounted for 93.3%, and the third sector accounted for only 6.7%. The length of uper branch is 15.2 mm and length of lower branch is 23.6 mm. Diameter of uper branch is 2 mm and lower branch is 1.7 mm. The distance from the angle of mandible to bisects the facial nerve is 40.8 mm. The facial nerve outside the retromandibular vein (86.7%). The anatomical features main body and branches of the facial nerve are no different compared to the authors in the world. The index in the study is different compared to the authors worldwide.

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KEYWORDS

Facial nerve; foramen stylomastoid; angle of mandible; retromandibular vein.

Introduction

The anatomical characteristics of the facial nerve in the parotid salivary gland and its branches and terminal branches have been studied by many authors, different racial or ethnic groups. Still, there are few accurate and detailed descriptions of these branches and terminal branches [1].

Many authors have found that the alteration of the original forms of the main body of the facial nerve and the division of branches are very variable [2]. Before entering the main body parotid gland, these branches are closely related to surrounding structures such as the posterior belly of the digastric muscle, mastoid process, angle of the

jaw, retromandibular vein, external carotid artery [3].

Therefore, surgeons need to accurately determine the position of the main body and its branches in the parotid gland. That is an important key in all surgeries involving parotid glands to minimize the risk of facial nerve damage. There are many methods to identify the main body of the VII cord based on anatomical landmarks such as mastoid process, posterior belly of digastric muscle, pointer cartilage, tympanomastoid fissure, retromandibular vein, etc. To do this, surgeons need reference anatomical landmarks to predict the safe position of the structures during surgery. These landmarks will guide the surgeon to easily identify and keep these landmarks during surgery, easily palpable on the patient, allowing the surgeon to quickly and safely identify anatomical structures for preservation.

Accordingly, this study was conducted to describe anatomical characteristics of the main body and branches of the facial nerve of an adult Vietnamese corpse, and identify some applied anatomical landmarks related to the main body and branches of the facial nerve.

Experimental

Study population

A cross-sectional descriptive study was conducted on 30 half-head cadavers of adult Vietnamese formol mummies, both male and female, at the Department of Anatomy, The Pham Ngoc Thach University of Medicine, from October 2022 to April 2023 with a sampling method of convenience on existing mummies populations.

Selection criteria were: (i) Vietnamese corpses, adults over 18 years old, (ii) the head, face, and neck area were intact; no surgery on this area, and (iii) no deformation, tumor, or abnormal head, and face and neck anatomy.

Exclusion criteria were: remove the deformed corpses with the head, face and neck, or the damaged corpses due to error dissections, or having surgical intervention in the face and parotid glands.

The surgical procedure and data collection method

Incision of the skin according to the outer ear canal - the outer corner of the eye, an incision in the orbital circle 3 cm from the upper edge of the orbit, an incision in the skin from the upper outer corner to the top of the outer ear canal, an incision in the upper temporal line. Make an incision along the earlobe to the lower edge of the jawbone, making an incision along the circumference of the mouth. Peel off the skin, expose the 2nd layer of the face, make an incision along the 2nd layer under the 3rd layer. The incision is perpendicular to the outer ear canal - the outer corner of the eye is 4cm from the outer ear canal, and the lower incision is along the mandibular border. These incisions provide access to the 3rd layer. 3rd layer dissection (SMAS) follows the incisions, upward to the zygomatic arch, to the zygomatic and orbital ligaments, and anteriorly to occlusal ligament, directed downward to the position of the mandibular ligament. Dissecting the SMAS layer was continued toward the eye sphincter, temple, nose, mouth, chin, and neck (Figure 1).

FIGURE 1 Dissection of the third layer (SMAS)

The 4th layer of the face was exposed, which is the layer below SMAS, dissect the parotid fascia, and pay attention to the facial nerve outputs. Afterwards, the anatomical structures was identified such as the mastoid process, the sternum, and the clavicle to mark the anterior border of the sternocleidomastoid muscle, and then anatomical landmarks such as the cartilage of the external ear canal, the posterior belly of digastric muscle were exposed. The main body of the facial nerve is usually located deep, 1 to 1.5 cm below the anterior inferior margin of the outer ear canal cartilage (also known as the pointer cartilage) and 1 cm deep below the midpoint of the posterior belly of digastric muscle. After identifying the main body of the facial nerve, a dissection was performed along the main body to identify the 2 temporal - zygomatic and cervical-facial branches, sometimes with a third branch. Dissection revealed the retromandibular vein and the external carotid artery.

Essential metrics to gather

- Relation of the retromandibular vein to the main body and branches of the VII nerve: The vein is located lateral or medial to the nerve.
- Relating to the superior and inferior branches of the facial nerve to the posterior maxillary vein;
- Relation of the external carotid artery to the main body and branches of the VII nerve: the artery is located lateral or medial the nerve;
- The number of branches of the temporal-zygomatic and cervical-facial;
- Determine the branched form of the main body according to Tsai [4] and the terminal branched form of the branch according to the classification of Davis [5].
- Distance of the facial nerve from the surface of the skin after coming out of the stylomastoid foramen;
- Angle between branches of cord VII: upper, middle, lower and other branches (if any); and
- Diameter and length of main body, upper branch, and lower branch;

All the above parameters are recorded in the data collection table (attached). An odd number was calculated and measured.

Research tools

Our data collection tools include Nikon D90 camera, Macro lens. Dissection kit includes a scalpel, surgical scissors, Kelly pliers, Allis pliers, tweezers with and without hook, single

hook, and double hook. Measuring tool set includes caliper, compass ruler, depth gauge, and protractor.

Data analysis

Correction of raw data from the collected table, coding variables, statistics and analysis using SPSS software version 19 with χ2 test, t-test. The numbers take one odd number after the comma, the p-value takes three odd numbers and compares with the p=0.05 value.

Results and discussion

We surveyed the 30 half-head cadavers, with females accounting for 33.3% and males for 66.7%, with an average age of 70. During the process of dissecting and locating the main facial nerve (VII) body, based on author Pereira's method using a triangle formed by the temporomandibular joint, the mastoid process and the angle of the mandible with a focal point, it allows for a quick and safe determination of the main facial nerve body [6]. These three anatomical landmarks can be identified by palpating during the dissection process. Throughout the dissection, we observed the classical method of finding the facial nerve by determining the posterior belly of the digastric muscle landmarks to establish depth, the mandibular angle, the posterior facial vein, and the "pointer cartilage" to locate the emergence of the main facial nerve from the stylomastoid foramen. Many authors have widely accepted this method due to its safety and preservation of the facial nerve. The correlation between the facial nerve and the posterior facial vein, as well as its bifurcation point concerning the mandibular angle and posterior belly of the digastric muscle, is easier to locate than the pointer cartilage, which presents the most challenging landmark to identify.

The anatomical characteristics of the main facial nerve

We found that 100% of the cadaver samples had only one body emerging from the stylomastoid foramen, and no cases with two main bodies were recorded which also did not report any instances of two main bodies. However, some foreign authors have reported the possibility of an additional main body. Katz found about 3% with the presence of two main bodies [7]. This requires conducting studies on cadavers with a large sample size and on imaging studies of Vietnamese individuals to determine whether the presence of additional main bodies is indeed present.

The right facial nerve is, on average, deeper from the skin surface after exiting the stylomastoid foramn at 28.9 mm, compared to its position on the left side, which is at 25.1 mm. This difference is statistically significant and serves as a warning for surgeons when performing procedures on the left side, similar to the observation that the facial nerve is more superficial in children. Therefore, the position of the VII nerve relative to the skin surface in our study appears deeper than that reported by Myint (ranging from 1 to 2 cm below the skin surface) [8]. This variation is influenced by multiple factors such as skin thickness, subcutaneous tissue, the superficial musculoaponeurotic system (SMAS) layer, sub-SMAS layer, and parotid gland tissue, which can vary depending on individuals and ethnic groups.

The average length of the main facial nerve body is 14.1mm, shorter than the findings of other studies. This variation may be due to individual and ethnic differences in the branching of the main body. Salame emphasized the importance of the main body length in nerve grafting, as this segment needs to be long enough to allow proper connections with other branches without being too tense or too slack [9].

The average number of branches that the main body separates is 2.1 branches on both sides, of which the proportion of main branches separating 2 branches accounts for the highest 93.3% and 3 branches account for only 6.7%; this finding is consistent with Myint's observation [8]. However, as Park and Lee advised, surgeons should be cautious even after identifying the main two branches, as there is still a possibility of the presence of a third branch, and if it is not taken care of, it can be damaged comparing the occurrence rate of 3 branches from the main body in our study (6.7%) with other studies. This difference could be influenced by ethnic factors, but it might also be due to the relatively small sample size, which prevents a definitive conclusion. However, identifying the possibility of the main body dividing into 3 branches (even at a low rate) still holds significance as a warning for surgeons to avoid overlooking and causing injury to this third branch.

We observed that the angle formed by the upper and lower branches of the main body is nearly perpendicular to each other, with a mean angle of 91.20 degrees, among which 66.7% had acute angles, and 33.3% had obtuse angles. This finding is in line with Myint's observation, as when the nerve reaches the posterior border of the upper jaw, it divides into two branches that are almost perpendicular to each other [8]. It also needs to be clarified that according to mathematical convention, an angle greater than 90° is an obtuse angle and vice versa is an acute angle. Still, in our study, most of the cases of the angle between the upper and lower branches have a small fluctuation around 90°, or in other words, this angle is almost square.

The length of the upper branch is 15.2 mm, much shorter than the lower branch, which measures 23.6 mm. The variation in the length of the lower branch can be attributed to the fact that, in our cadaver samples, the lower branch travels a relatively long distance after separating from the main body before branching into the lower mandibular branch, cervical branch, or anastomotic branch. This individual variation may be due to unique anatomical characteristics in each case. Regarding the diameter, the upper branch has an average diameter of 2 mm, while the lower branch is 1.7 mm. However, when we performed a paired t-test to compare the diameters, we found no statistically significant difference with $p>0.05$, indicating that the upper and lower branch diameters are similar and do not significantly differ. Compared with a study in Vietnam, the diameter of the upper branch in their research is 1.94 mm, similar to our findings, but the diameter of the lower branch is smaller at 1.07 mm. Contrary to some foreign authors such as Myint, where the upper branch is the larger branch, nearly twice the size of the lower branch [8].

There are three anatomical variations in the division of the main facial nerve body according to Tsai's classification [4]:

+ *Type 1*: The main body divides into upper and lower branches, followed by the further division of the lower jaw branch and cervical branch, accounting for 20.0% on both sides.

+ *Type 2*: Accounts for the highest proportion of 60.0% on the right side and 66.7% on the left side. The main body divides into upper and lower branches, which further divides into 5 classical branches.

+ *Type 3*: Accounts for 20.0% on the right side and 13.3% on the left side. At the position of the division of the upper and lower branches of the facial nerve, additional branches emerge

In our study sample, the rate of type 2, according to Tsai accounted for the majority of over 60% on both sides. The ratio between forms did not have a statistically significant difference, while forms 1 and 3 each divided equally about 20% (Table 1). Compared with Tsai, type 1 (with the main body divided into upper and lower branches, followed by the bifurcation of the mandibular and cervical

branches) accounted for 24.7%, respectively. In comparison, type 2 (the main body is divided into upper and lower branches, then these branches are divided into 5 classic branches), with the highest proportion of 42%, is lower, form 3 (at the position of dividing the upper and lower branches into two branches here) is 33.3%, higher than our group 3. If compared to another study, tense type 1 (corresponding to form 2 Tsai) is 82%; type 2 (corresponding to 3 Tsai form) accounted for 6%, and type 3 (corresponding to 1 Tsai form) accounted for 10%. Thus, although the ratio differs, it is still agreed that type 2 accounts for the highest percentage.

TABLE 1 Comparison of the proportions of the three anatomical variations in the division of the main facial nerve body (according to Tsai) with some authors

Author	Type 1 (%)	Type 2 (%)	Type 3 (%)
Tsai [4]	24.7	42.0	33.3
Our study	20.0	60.0	20.0

Methods for identifying the main body of the facial nerve and applications

According to our research, the distance from the angle of the jaw to the bifurcation position of the facial nerve is 40.8 mm. The rod is 38.6 mm. This can be explained because both authors studied Vietnamese people, so the length of the lower jaw bone did not change much. Still, according to some other authors, this gap is longer in Caucasians than in Asians because Caucasians's body are bigger and their lower jaw is bigger and stronger. However, our distance from the angle of the jaw to the bifurcation position is longer than that of foreign authors such as Myint is 28.06mm (varies from 11-40 mm) [8], Davis *et al.* is 32 mm (25-45 mm) [5]. Is it possible that the main body of the facial nerve is located higher in the Vietnamese than in other ethnic groups? For accurate conclusions, a study with a large sample is needed, and a comparison of the position of the main body and the angle of the jaw relative to the zygomatic arch is required.

Furthermore, the distance from the angle of the jaw to the division point of the facial nerve in the range of 36-50 mm is equally distributed on both sides, accounting for 86.6%. This variation is also significantly different and higher than Myint K's findings, which reported that the distance from the lower jaw angle to the division point of the facial nerve, in the majority (81.0%) of cases, was in the range of 21-35 mm above the jaw angle [8].

We found the distance from the angle of the jaw to the bifurcation of the facial nerve to range from 31-55mm and that of Myint from 11-40 mm, which means that if we use a 5mm interval, there is a value may be omitted [8], so in the following studies, we should calculate the ratio of the distance from the main body division to the entire segment length to the mandible, which is more meaningful (Table 2). Determining the distance from the angle of the jaw to the bifurcation is very important in clinical practice because it helps to avoid damage to the facial nerve during parotid surgery.

TABLE 2 Comparing the classification of the distance from the angle of the jaw to the division point of the facial nerve with Myint's findings

The classification of the distance (mm)	Myint [8]		Our study	
	Frequency	Proportion (%)	Frequency	Proportion (%)
11-15	3	3.8	0	0
16-20	6	7.6	0	0
21-25	12	15.2	0	0
26-30	30	38.0	0	0
31-35	22	27.8	3	10.0
36-40	6	7.6	14	46.7
41-45	0	0	8	26.7
46-50	0	0	4	13.3
51-55	0	0	1	3.3
	79	100.0	30	100.0

We found that 86.7% of both sides of the facial nerve were located outside the posterior maxillary vein and found a statistically significant difference in the position of the facial nerve and the posterior maxillary vein on both sides with p=0, 03. This means that the position of the main body of the facial nerve with the posterior maxillary vein is not the same on the right and left sides. This result is consistent with Curtin's finding that 83% of the facial nerve is located outside the posterior maxillary vein, and the remaining 17% is located inside the vein, and this relationship is not the same between the right and left sides [10].

In over 80% of both sides, the superior facial nerve branch was located outside the posterior maxillary vein, and there was a statistically significant difference in the position of the superior facial nerve branch with the posterior maxillary vein on both sides. The sub-facial branch located outside the posterior maxillary vein was also over 80% on both sides, and there was no statistically significant difference in the position of the sub-facial nerve branch with the posterior maxillary vein on both sides. Consistent with Kim *et al.*, the inferior major branches of the facial nerve mostly go lateral to the retromaxillary vein (83%) and a few (17%) go inside the vein [11]. As for Wang *et al.*, 100% of the mandibular branch goes laterally in the superficial layer than the retromaxillary vein [12]. Associates found that the cervicofacial sector runs outside the posterior maxillary vein. Thus, although there is a difference in the proportion of each type, most of the authors found that for over 80% of the main body, the upper, and lower branches run outside the posterior jaw vein and the position of the facial nerve compared to the ventral plexus has may not be the same on the right and the left. In addition, we found no difference in the position of superior and inferior facial nerve with the posterior mandibular vein on the right, but there was a difference in the position of superior and inferior facial nerve with the posterior mandibular vein on the left with p=0.024. It shows that in the same individual, the superior and inferior physeal positions with the retromandibular vein may not be the same on the same side or on the other side, the relationship between this venous nerve seems to be irregular, typically.

In particular, Toure G *et al.*, found that there were 4 cases of posterior maxillary vein forming a ring in which the main body of the facial nerve penetrated this ring (2 cases), and in the remaining 2 cases, the inferior branch penetrated this vein ring [13]. Curtin noted a case where the posterior maxillary vein formed two rings, and the superior and inferior branches of the facial nerve passed through this ring [10]. This is in contrast to our study that noted that the branch of the facial nerve forms a ring around the posterior maxillary vein, so having these cases will

increase the risk factor for facial nerve damage or bleeding at the time of parotid gland tumor removal surgery. The facial nerve travels outside the vein in a normal anatomical position, so there is less risk of bleeding due to nerve damage. But in the special form, where the retromaxillary vein goes outside the main body or branches of the facial nerve, the risk of bleeding and nerve damage will be much higher in surgery to remove parotid adenomas.

Applied in otolaryngology, it was used the retromaxillary vein to identify the facial nerve by identifying the retromaxillary vein in the neck region and dissecting it gradually ascending to the inferior branch of the facial nerve and is usually superficially outside the posterior maxillary vein, after identifying the sub-branch of the main facial nerve, the facial nerve was identified and revealed. This is the method used by many authors around the world. Ariyoshi and Shimahara gave criteria based on the posterior maxillary vein; if this vein is pushed inward or the vein is not displaced and the tumor location is outside this vein, then the tumor is considered a superficial lobe [14]. The posterior maxillary vein is used as a landmark to identify the facial nerve in diagnostic imaging and this method has an accuracy of 86.4%. Therefore, the awareness that there exists an altered relationship between the facial nerve and the posterior maxilla is important in assessing the safety of surgery before surgery and determining the location of the adenoma ears. This prediction is not 100% guaranteed.

Conclusion

Regarding the anatomical characteristics of the main body and branches of the facial nerve, we recorded that all the body samples had only 1 common body exiting from the mastoid foramen. There were no cases with 2 or more common bodies. The facial nerve is deeper from the skin surface after exiting the mastoid foramen on the right side than on the left, thus requiring more attention during surgery. The main body length is 14.1 mm, the diameter is 2.5 mm, the average number of branches separating the main body is 2.1 branches, in which the proportion of main body separating the two branches accounts for the highest 93.3%, and it is noted that there is still the possibility of may present a third sector and may injure it during surgery. The angle formed by the upper and lower branches of the main body is almost perpendicular to each other 91.20, and the upper branch length of 15.2 mm is much shorter than that of the lower branch 23.6mm. We found that the rate of type 2, according to Tsai is over 60%. To determine the main body and branches of the facial nerve, we found that the distance from the angle of the jaw to the bifurcation of the facial nerve was 40.8 mm longer than that of foreign authors due to the bifurcation location. The main body is located higher and the distance of the bifurcation is from 36-50mm, accounting for 86.6%; from which to avoid damage to the facial nerve during parotid surgery, the surgeon can determine the bifurcation of the main body of the facial nerve along the posterior border of the mandible to the angle of the jaw. Approximately 86.7% of both sides of the facial nerve located outside the posterior maxillary vein had a statistically significant difference in bilateral location. Over 80% of the superior and inferior facial nerve branches were located outside the retromandibular vein, from which we have found that in the same individual, the superior and inferior branches of the retromandibular vein may not be the same on the same side or different. On the other hand, this venous relationship seems to be irregular. In addition, we also noted that the branch of the facial nerve forms a ring around the posterior maxillary vein. Therefore, these cases will increase the risk of facial nerve damage or bleeding when parotid adenoma is removed.

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Authors' Contributions

The authors have the same contribution to the stage in editing the manuscript and are responsible for all aspects of this work.

Conflict of Interest

The authors declare that they have no conflict of interest in this study.

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