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ARAŞTIRMA / RESEARCH

Morphological evaluation of terminal branches of the facial nerve within the parotid gland in fetus cadavers

Fetus kadavralarında parotid bez içerisindeki fasiyal sinirin terminal dallarının morfolojik değerlendirilmesi

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Abstract

Purpose: The aim of present study was to describe the branching pattern of the facial nerve according to interconnections between the branches, to examine the number of terminal branches, to determine anatomical variations and to emphasize the importance of these in terms of pediatric parotid surgery.

Materials and Methods: Thirty-two parotid regions from eight female and eight male fetus cadavers (gestational ages between 21.0 and 35.5 weeks according to foot lengths) were dissected. The branching pattern of the facial nerve, terminal branch numbers and interconnections between the branches were examined and described. In present study, the facial nerve was classified using Davis et al.' classification. But, we encountered interconnections between facial nerve branches that were not mentioned previously and the branching patterns formed by these interconnections were named as Type x and Type y.

Results: Out of the total 32 cases, 13 (40.63 %) were Type I, 7 (21.88 %) were Type II, 3 (9.38 %) were Type III and 5 (15.63 %) were Type VI. Type IV and Type V were not encountered. Type x were in 2 (6.25 %) cases and Type y were in 2 (6.25 %) cases. The mean total number of nerve terminal branches was 7.90 ± 1.49.

Conclusion: Investigation outcomes presented in this study have defined branching pattern and anatomical variations of the facial nerve branches and can be assist with the protection of the nerve during surgical procedures and prevent surgery-associated damage to the nerve, and thus facial paralysis.

Key words: Facial nerve, anatomical variation, branching pattern of the facial nerve, cadaver dissection, surgical anatomy.

Öz

Amaç: Bu çalışma fasiyal sinirin dallanma şeklini dalları arasındaki bağlantılara göre tanımlamak, terminal dal sayısını incelemek, anatomik varyasyonlarını belirlemek ve pediatrik parotid cerrahisi açısından önemini vurgulamak için yapılmıştır.

Gereç ve Yöntem: 8 kadın ve 8 erkek fetus kadavrasının (ayak uzunluklarına göre, yaşları 21.0 ile 35.5 gestasyonel hafta arasında) 32 parotid bölgesi diseke edildi. Fasiyal sinirin dallanma şekli, terminal dal sayısı ve dalları arasındaki bağlantılar incelendi, tanımlandı. Bu çalışmada, fasiyal sinir Davis ve ark.'nın sınıflandırmasına göre sınıflandırıldı. Fakat, fasiyal sinirin dalları arasında daha önce bahsedilmeyen bağlantılarla karşılaşıldı ve bu bağlantıların oluşturduğu dallanma şekilleri Tip x ve Tip y olarak adlandırıldı.

Bulgular: 32 vakanın 13 (%40.63)'ü Tip I, 7 (%21.88)'si Tip II, 3 (%9.38)'ü Tip III ve 5 (%15.63)'I Tip VI idi. Tip IV ve Tip V tanımlanmadı. Tip x, 2 (%6.25) vakada ve Tip y de 2 (%6.25) vakada tanımlandı. Fasiyal sinirin terminal dallarının ortalama sayısı 7.90 ± 1.49 idi.

Sonuç: Çalışmadan elde edilen araştırma sonuçları fasiyal sinirin dallanma şeklini ve anatomik varyasyonlarını tanımlayarak cerrahi müdahalelerde sinirin korunmasına yardımcı olabilir, cerrahi ile ilişkili sinir hasarını ve dolayısıyla da fasiyal paraliziyi önleyebilir.

Anahtar kelimeler: Fasiyal Sinir, anatomik varyasyon, fasiyal sinirin dallanma şekli, kadavra diseksiyonu, cerrahi anatomi.

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INTRODUCTION

Partial or total parotidectomy is often required to excise tumors in the human parotid gland. These operations involve considerable risk, however, due to the close relationship between the gland and the facial nerve, which supplies the muscles of expression[1]. Facial paralysis is a complication of parotid region surgery that can have life-altering consequences. Identification and exposure of the facial nerve is of crucial importance before excision of parotid tumors. However, facial nerve palsy still develops after parotid surgery despite recent technological advances[2]. Parotid gland surgery therefore needs to incorporate identification of the facial nerve. This means that the facial nerve is to be exposed because of invasion by tumor, it should be identified and preserved before the excision of a diseased gland[3]. The surgeon needs an excellent understanding of the anatomy of the facial nerve if injury is to be avoided during facial surgery. Surgeons need to perform careful dissection of the facial nerve branches, bearing in mind potential anatomic variations, in order to reduce injury to the nerve during parotid surgery. A knowledge of facial nerve anatomy is therefore essential[4-6]. Facial nerve preservation during parotid surgery depends upon its exposure and the surgeon's ability to locate it without damaging it. Detailed knowledge of the nerve anatomy and great peri-operative care are essential if trauma is to be avoided[7]. Parotid surgery is reported to be a common cause of pediatric facial paralysis[8].

Several previous studies have investigated the divisions and origin of the facial nerve. However, the facial nerve branching within the parotid gland has clinical significance, especially in parotid surgery, since it has many variations in this region[9]. The formation of interconnections between the branches results in considerable diversity. Interconnections are most frequent between the zygomatic and buccal branches[10]. The literature contains numerous descriptions of variations in facial nerve anatomy. The classification of the branching of the facial nerve within the parotid gland is that by Davis et al.[11] and Katz & Catalano[6] performed classifications that is still valid today[12]. Facial nerve arborization is well known. However, there are no standard descriptions of the highly complex patterns found in the frontozygomatic and cervicofacial divisions. However, a detailed anatomy knowledge of facial nerve is essential in the light of recent sophisticated approaches in facial surgery[13].

The extratemporal section of the facial nerve, either inside or outside the parotid gland, is an exceedingly complex structure. This complex structure also neighbors on other important structures. A detailed knowledge of the variations in the nerve will reduce complication rates[12,14,15]. Interconnections exist between the upper and lower branches of the facial nerve. In cases with interconnections, even if in this region damage occurs to some branches of the nerve during surgical procedures, the resulting palsy of facial musculature is minimal, or else may not occur at all[2,16].

This study was carried out to identify the pattern of facial nerve branching within the parotid gland according to interconnections between the branches and anatomical variations and to empasize their significance in pediatric surgical procedure.

MATERIALS AND METHODS

This study was performed at the Anatomy Department of Medical Faculty. The study protocol was approved by the Ethics Committee of the Medical Faculty. 16 fetus cadavers (eight females, eight males) with no visible external abnormalities or pathologies preserved in 10% formaldehyde in the department laboratory were used. Fetuses' ages were identified between 21.0 and 35.5 gestational weeks (gw) according to their foot lengths on the basis of Mercer et al.'s [17] study and mean age was 29.80 ± 4.29 gw.

Dissection

Dissections were performed on 32 hemifaces (16 fetus cadavers) in the semilateral position. A pre-auricular incision was performed extending to the lobulus auriculae and down to the neck. The skin and subcutaneous tissue were removed. Then, the platysma and sternocleidomastoid muscles was identified and retracted.

The facial nerve trunk was identified and was traced towards its two main trunks (the tempofacial and cervicofacial). The upper and lower trunks and all branches were dissected throughout the parotid gland, which was removed (Fig. 1 and 2). All branches of the facial nerve and the pattern of upper and lower trunks with all interconnections were recorded. Facial nerve branches were analyzed separately. The

number of the facial nerve terminal branches was calculated.

Branching pattern of the facial nerve

The facial nerve was classified using Davis et al.'[11] classification in present study. According to Davis et al.[11] branching pattern of the facial nerve is categorized into six types as follows (Figure 1):

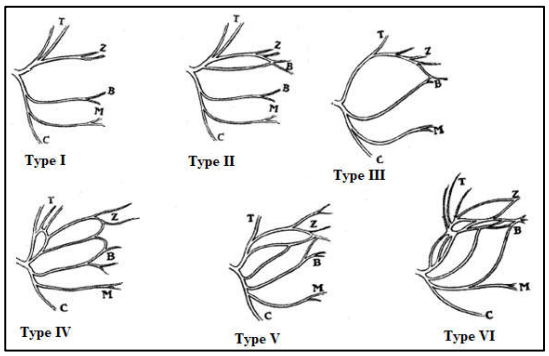

Figure 1. Davis et al.[11]'s classification to facial nerve.

T: temporal branch, Z: zygomatic branch, B: buccal branch, M: marginal manibular branch and C: cervical branch.

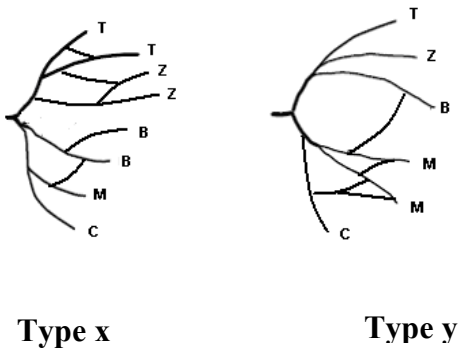

Figure 2. Type x and Type y. Branching patterns and interconnections that are different from previous studies.

T: temporal branch, Z: zygomatic branch, B: buccal branch, M: marginal mandibular branch and C: cervical branch.

Type I: There was no anastomosis between the facial nerve branches

Type II: There was an anastomotic interconnection between branches of the temporofacial trunk

Type III: There was only an anastomotic interconnection between temporofacial and cervicofacial trunks

Type IV: It was a combination of Type II and Type III

Type V: There were two anastomotic interconnections between temporofacial and cervicofacial trunks

Type VI: It was a plexiform structure, in which marginal mandibular branch joined any branch of the temporofacial trunk

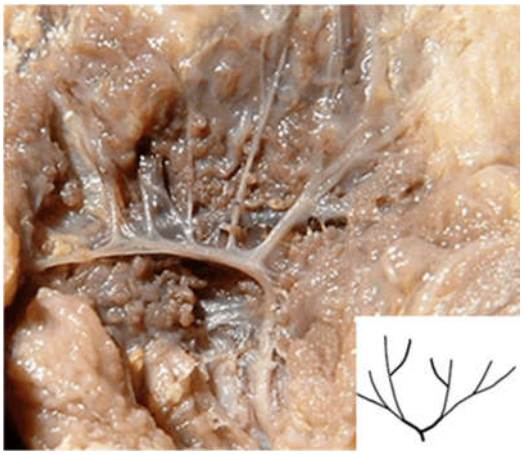

Figure 3A. Type I branching pattern and terminal branches of facial nerve in left hemiface.

Figure 3B. Type VI branching pattern and terminal branches of facial nerve in right hemiface.

But in present study, it was encountered interconnections between facial nerve branches that were not mentioned in previous studies and the branching patterns formed by these interconnections were named as Type x and Type y (Figure 2).

Type x: There were anastomotic interconnections between branches belonging to temporofacial and cervicofacial trunks.

Type y: There were anastomotic interconnections between branches of the cervicofacial trunk and there was an anastomotic interconnection between temporofacial and cervicofacial trunks.

During the evaluation of branch numbers after the dissection, some branches of the left temporofacial trunk in one of the female fetus cadavers and some branches of the right temporofacial trunk in another female fetus cadaver were damaged, so these parts were not included this section of the study.

Statistical analysis

SPSS 22.0 (Statistical Package for Social Sciences) software was used for descriptive statistical analysis of data in present study.

Table 1. Mean number of the facial nerve branches

Facial Nerve Branches	Min - Max (Range)		Mean ± SD
Temporal	1	3	1.23 ± 0.50401
Zygomatic	1	2	1.26 ± 0.44978
Buccal	1	4	2.46 ± 0.81931
Marginal mandibular	1	2	1.20 ± 0.40684
Cervical	1	3	1.73 ± 0.63968

Table 2. Percentage distributions and numbers of the facial nerve branches

Facial Nerve Branches	Branch Number	Female cadavers			Male cadavers (n=8)			All cadavers (n=16)		
		Right n/%	Left n/%	Total n/%	Right n/%	Left n/%	Total n/%	Right n/%	Left n/%	Total n/%
Temporal	1	6/75	5/71.43	11/73.33	6/75	8/100	14/87.5	12/75	13/86.67	25/80.65
	2	2/25	2/28.57	4/26.67	1/12.5	-	1/6.25	3/18.75	2/13.33	5/16.13
	3	-	-	-	1/12.5	-	1/6.25	1/6.25	-	1/3.22
Zygomatic	1	6/75	4/57.14	10/66.67	6/75	7/87.5	13/81.25	12/75	11/73.33	23/74.19
	2	2/25	3/42.86	5/33.33	2/25	1/12.5	3/18.75	4/25	4/26.67	8/25.81
Buccal	1	3/37.5	-	3/20	-	1/12.5	1/6.25	3/18.75	1/6.67	4/12.90
	2	3/37.5	3/42.86	6/40	3/37.5	4/50	7/43.75	6/37.5	7/46.67	13/41.94
	3	2/25	2/28.57	4/26.67	4/50	3/37.5	7/43.75	6/37.5	5/33.33	11/35.48
	4	-	2/28.57	2/13.33	1/12.5	-	1/6.25	1/6.25	2/13.33	3/9.68
Marginal mandibular	1	7/100	7/87.5	14/93.33	5/62.5	6/75	11/68.75	12/80	13/81.25	25/80.65
	2	-	1/12.5	1/6.67	3/37.5	2/25	5/31.25	3/20	3/18.75	6/19.35
Cervical	1	2/28.57	4/50	6/40	2/25	4/50	6/37.5	4/26.67	8/50	12/38.71
	2	5/71.43	4/50	9/60	4/50	3/37.5	7/43.75	9/60	7/43.75	16/51.61
	3	-	-	-	2/25	1/12.5	3/18.75	2/13.33	1/6.25	3/9.68

Table 3. Comparison of branching pattern of the facial nerve with former studies according to Davis et al.[11] classification

Previous Studies	Type I %	Type II %	Type III %	Type IV %	Type V %	Type VI %
Davis et al. 11	13	20	28	24	9	6
Park & Lee16	6	14	33	23	6	17
Bernstein & Nelson14	9	9	25	19	22	16
Kitamura & Yamazaki18	43	17	10	30	-	-
Gataa & Faris9	16.2	23.2	30.2	18.6	4.6	6.9
Present study	40.63	21.88	9.38	-	-	15.63

RESULTS

Branching pattern of the facial nerve

Out of the total 32 cases, 13 (40.63 %) were Type I, 7 (21.88 %) were Type II, 3 (9.38 %) were Type III and 5 (15.63 %) were Type VI. Type IV and Type V were not encountered. The most common branching pattern of the facial nerve was identified as Type I. Besides, 2 (6.25%) cases were Type x and 2 (6.25 %) cases were Type y (Figure 2).

In addition, out of the 16 fetuses, 5 (31.25 %) were bilaterally the same type of branching patterns, 11 (68.75 %) were bilaterally different branching patterns (Figure 3A and 3B).

Number of the facial nerve branches

The mean total number of nerve terminal branches varied from 6 to 11 (mean, 7.90 ± 1.49). The mean number of temporal branch was 1.23 ± 0.50. The mean number of zygomatic branch was 1.26 ± 0.44. The mean number of buccal branches was 2.46 ± 0.81. The mean number of marginal mandibular branch was 1.20 ± 0.40. The number of cervical branch varied from 1 to 3 (mean, 1.73 ± 0.63) (Table 1). Percentage distributions and numbers of the facial nerve branches were presented Table 2 in female, male and all fetus cadavers.

DISCUSSION

This study was performed to investigate the branching pattern and branch numbers of the facial nerve in parotid gland. The facial nerve must be identified and protected for successful facial surgery. The variations in facial nerve branching may complicate to surgery, so it is important to describe the interconnections between the branches of the facial nerve in detail[9]. The facial nerve is at potential risk in several procedures performed on the face, and its peripheral branches exhibit considerable variation[14].

The course of the facial nerve inside the parotid gland exhibits considerable variation and gives rise to a structure known as the 'parotid plexus'. This plexus is divided into general types based on presence or absence of anastomosis between the temporofacial trunk and cervicofacial trunk. In types with anastomosis, even if some branches along the nerve are damaged during surgical manipulation, the paralysis emerging in the facial muscles is minimal or else non-existent. In clinical practice surgeons seek to entirely remove the diseased parotid gland without injuring the facial nerve, but this is very difficult in terms of the anatomy of both the parotid gland and the facial nerve.

The facial nerve exhibits complex branches and patterning, as presented in textbooks. For example, among the authors who investigated the branching patterns of the facial nerve, Davis et al.[11] described six type patterns in 350 hemifaces. The most common type (Type III, 28% of cases) had a single interconnection between the temporofacial and cervicofacial trunks. Kitamura and Yamazaki classified the branches of the facial nerve according to the classification described by Davis et al.[11] and described Type I as the most widespread branching pattern[18]. In Park and Lee's study, it was cited as Type III[16]. Interconnections between facial nerve branches of 35 specimens determined into three types in Bernstein and Nelson's study. These were the zygomatic-buccal type, involving zygomatic and buccal branches in 72%, the buccal-buccal type with anastomoses only between buccal branches in 19% and the zygomatic-mandibular type with anastomoses between zygomatic, buccal and marginal mandibular branches in 9% and they described Type III as the most widespread branching pattern[14]. In Gataa and Faris's study, the facial nerve branching pattern of 43 cases used Davis et al. [11]' classification and described Type III as the most common type[9].

Katz & Catalano[6] studied branching patterns of the facial nerve in 100 cases and classified them in five groups. They identified Type III, which they described as the most widespread anatomical type in 44% of cases. Authors in previous studies examined 50 facial nerves, analyzing the intraparotideal branching using the Katz & Catalano[6] classification and described Type IV as the most widespread type[12,19]. In addition, this authors reported the facial nerve exhibiting the same branching pattern bilaterally at levels of 76% and, 52.7% respectively [12,19].

Ekinci examined 27 facial nerves, divided these into five types and reported encountering Type I and Type IV most in that classification, and that 54% of facial nerves had the same branching pattern bilaterally[20]. Kwak et al. investigated branching inside the parotid gland in 20 facial nerves and reported a range of variations in facial nerve branching and

classified the facial nerve under four types, depending on the origin of buccal branch. Also, the authors emphasized interconnections between zygomatic and buccal branches in Type II and Type IV at a frequency of 70%, and between buccal and marginal mandibular branches in Type III and Type IV at a frequency of 42%[21]. In a Farahvash et al.'s study dividing 42 facial nerve into four types, Type I was described as the classic type. In Type II, buccal branches were branched from the marginal mandibular branch. In Type III the temporal, zygomatic and buccal branches were branched from the main trunk. In Type IV, the buccal branches were branched from the temporozygomaticobuccal branch[5].

Present study investigated branching pattern, branch numbers and interconnections between branches of the facial nerve by dissecting the parotid region of the fetus cadavers. We used Davis et al.[11]'s classification and 13 (40.63%) were Type I, 7 (21.88%) were Type II, 3 (9.38%) were Type III and 5 (15.63%) were Type VI (Figure 1). Type IV and Type V were not encountered. Besides, 2 (6.25%) cases were Type x and 2 (6.25%) cases were Type y (Figure 2). Type I was identified as the commonest branching pattern of the facial nerve. In terms of the commonest branching pattern of the facial nerve, our results are similar to those of Kitamura & Yamazaki[18]. The comparison between the present study and former studies using Davis et al.[11]' classification is presented Table 3. In addition, out of the 16 fetus cadavers, 5 (31.25%) were bilaterally the same type of branching patterns, 11 (68.75%) were bilaterally different branching patterns. Our study approved the diversity in distribution and branching pattern of the facial nerve.

Due to the locations and courses of the temporal and marginal mandibular branches, there is a high level of injury to these branches during surgery, and these branches have been examined comprehensively by several authors. Gardetto et al. examined parotid regions in 10 cadavers and calculated the number of facial nerve branches and reported two temporal and two zygomatic branches in 50% of 20 specimens, two or more buccal branches in 95% and only one marginal mandibular branch in 90%[10].

Several studies investigated the temporal branch of the facial nerve and emphasized that the number of the temporal branch generally varies between 2 and 6[14, 22-24]. Authors examined the marginal mandibular branch of the facial nerve and reported that the number of branches ranges between 1 and 4 in previous studies[4,25-28]. Schwember and Rodriguez investigated the number of terminal branches of 30 facial nerve and described the facial nerve as having at most 16 branches (2 temporal, 3 frontal, 2 palpebral, 2 zygomatic, 3 buccal, 2 marginal mandibular and 2 cervical). They encountered facial nerves of 6 branches in all 30 cases[29].

Erbil et al. examined zygomatic and buccal branches of the facial nerve in 10 cadaver dissections, zygomatic branch was double in 7 cases and single in 3. The buccal branch was single in 4 of the cases and double in 6 of the cases[30]. Tzafetta and Terzis investigated the number of branches and interconnections of facial nerve branches in 10 cadaveric hemifaces and reported that the temporal branch had a mean nerve number of 2.80 ± 0.63, the zygomatic branch 4.40 ± 1.34, the buccal branch, 3.20 ± 0.78 and the marginal mandibular branch 2.30 ± 0.48. They did not examine the cervical branch of the nerve. They reported a marginal mandibular branch in 21% of cases in their study, and two or more major branches in 79% of cases[13]. Farahvash et al. reported between 1 and 3 temporal branches, and that the marginal mandibular branch was usually a single branch, with more than one branch in only 2 out of the 42[5].

In present study, following dissection of the 32 facial nerve, the facial nerve had 11 branches at most (3 temporal, 1 zygomatic, 4 buccal, 1 marginal mandibular and 2 cervical) (Table 1 and 2). In addition, at most 3 temporal branches, 2 zygomatic branches, 4 buccal branches, 2 marginal mandibular branches and 3 cervical branches were seen to originate from the facial nerve. It is very important to be aware of facial nerve branching and the possible variations in regions of the facial nerve inside the parotid gland in order to reduce facial paralysis during parotidectomy procedures to a minimum.

In conclusion, facial paralysis is the most feared complication of parotid region surgery. Surgeons must therefore pay detailed attention to the anatomy of the region and the facial nerve. Detailed knowledge of the anatomy of the facial nerve during surgical procedures is of vital importance for the protection of the nerve. We think that these significant variations in branching pattern and branches of the facial nerve will be of considerable assistance in pediatric surgical procedures to facial nerve in particular.

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