LABORATORY INVESTIGATION

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A Morphological Analysis of the Facial Nerve in Korean Fetuses and Stillborn Infants

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Objective : The accurate anatomy of the facial nerve is essential for successful surgical outcome. The purpose of the present study is to know such information on the facial nerve from a series of specimens.

Methods : This study is based on cadaveric dissection of 41 Korean fetus and stillborn infant and describes anatomical variations of the peripheral branches of the facial nerve that pose a importance in a number of neruosurgical procedure.

Results : The branching patterns were classified into six types according to modified Davis classification : the frequencies of occurrence were : type I, 4.9%; type II, 24.4%; type III, 34.1%; type IV, 19.5%; type V, 12.2%; and type VI, 4.9%. Types II, III and IV together accounted for almost 80% of the specimens.

Conclusion : Compared to previous adult and western stillborn fetus cadaveric studies, there was no significant difference in the percentage of the types between the subjects in the present study, similar pattern and anatomic distribution.

KEY WORDS : Facial nerve · Fetus · Anatomy.

Introduction

In case of neurosurgical or facial surgery, many surgeons have attempted to eliminate the possibility of facial nerve injury, but this has proved to be very difficult because of varied anatomical structure of the facial nerve[5,9,10]. While injury to the facial nerve is not vitally damaging, the resultant deformity poses great psychologic problems to the patient and relatives. Therefore, surgeons must be familiar with the normal relationships between the anatomical disposition of the facial nerve and the various surface landmarks in the face.

In order to define the nature of this relationship, many studies have been made on dissected adult specimens, wherein, site, course, branches and variations have been widely discussed; however, little attention has been paid to such anatomical considerations in newborn infants[18]. Moreover, the study of the anatomy of the facial nerve has not been performed in Oriental fetuses and infants. This report, based on the careful and precise cadaveric dissection of 41 Korean fetuses and stillborn infants cadavers, describes the anatomical positions of the peripheral branches of the facial nerve that pose a potential danger to successful operations on the face.

The purpose of the present study was, therefore, to provide such information on the facial nerve as accumulated from a series of specimens.

Materials and Methods

Fine cadaveric dissections were performed on 41 formalin-fixed Korean fetus and stillborn infant. The specimens were preserved in the morgue of the Department of Anatomy, and included 26 males and 12 female fetuses, between 30 and 38 weeks of age, and 3 male stillborn infants. Only specimens with a complete dissection of the facial nerve were included. No attempt was made to study bilateral configurations. Whenever possible, we dissected the facial nerves as far distally as their main trunk (Fig. 1). Despite the use of a magnifying loupe (×4.5 magnification), dissection of the small terminal branches was difficult or impossible in some cadavers. Before dissection, the facial roentgenograms were made.

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Fig. 1. Deep dissection of the 38 weeks fetus cadaver face after removal of the entire superficial part of the parotid gland. Showing the variegated appearance of facial nerve branching.

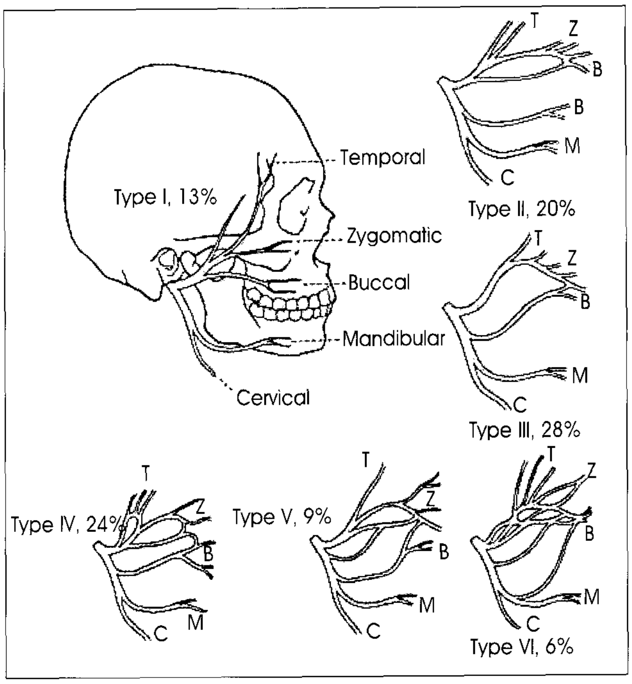

Fig. 2. Types of facial nerve branching (modified from Davis RA et al.[3]).

Fig. 3. Roentgenogram of a stillborn infant. Arrow indicates very poorly developed mastoid process.

The dissections were performed in layers, with the exception of the parotid gland, the parotid fascia and the superficial lobe of the parotid gland were removed as en bloc. The facial nerve trunk was dissected backwards to the anterior border of the sternocleidomastoid muscle, where it was reflected downward, the nerve trunk was then traced to the stylomastoid foramen. The original position of the facial nerve was maintained at all times. Bony landmarks were exposed by sectioning the overlying facial nerve and the surrounding soft tissues in blocks, and spatial relationships between bony landmarks of relevance to the location of the facial nerve were determined.

The following details were recorded : major types of facial nerve branching and anastomosis, numbers of rami of the temporal and mandibular branch of the facial nerve, anatomical relationship between the branch and its adjacent stuctures, and the relation between the distance of various anatomical points and the facial nerve (Fig. 2, 3).

Results

The course and position of the facial nerve

The trunk of the facial nerve exited from the stylomastoid foramen and passed directly forward to its bifurcation. In specimens showing a lack of mastoid process development, the insertion of the sternocleidomastoid muscle covered the origin of the posterior belly of the digastric muscle, which, in turn, covered the stylomastoid foramen. The styloid process was poorly developed in all specimens. The trunk of the facial nerve divided after passing beneath the posterior belly of the digastric muscle and over the transverse process of the atlas. The trunk of the facial nerve lay within the parotid gland from the stylomastoid foramen to its bifurcation and passed just below the deep portion of the cartilaginous external auditory canal. The terminal portion of the facial nerve, within the substance of the parotid gland, divided to create a tem-

Fig. 4. Diagram showing anatomical points used for measurements. A : external auditory orifice, B : mastoid process, C : bifurcation of the facial nerve, D : mandibular angle, E : nasion, F : anterior nasal spine, G : mentum.

porofacial and a cervicofacial division. The distance from the external auditory orifice to the bifurcation of the facial nerve ranged from 5 to 11mm. The length of the facial nerve trunk ranged from 9 to 15mm.

Types of branching and anastomosis of the facial nerve

The observed branching patterns were classified into six types as described by Davis et al.[3] : as follows : the frequency of occurrence was type I in 4.9%, type II in 24.4%, type III in 34.1%, type IV in 19.5%; type V in 12.2%, and type VI in 4.9%. Types II, III and IV together accounted for almost 80% of the specimen (Fig. 4, Table 1). With the exception of one specimen, anastomoses were observed between the cervicofacial and temporofacial rami of the facial nerve. The peripheral anastomosis between individual branches were revealed, at the following rates : temporozygomatic branch in 19.5%, zygomaticobuccal branch in 66.7%, and the buccal and mandibular branch in 13.9%.

The anatomy and number of the rami

The number rami of the temporal branch of the facial nerve was found to be between 1 and 4, and the mean number of rami was 2.6 (Table 2). These rami were evenly distributed, with the posterior-most ramus always anterior to the superficial temporal vessels. The distance between the auricle-scalp junction and the superficial temporal vessels ranged from 3 to 7mm. In 36 of 41 specimens, we identified mandibular branches at or above the inferior border of the mandible when theses branches passed over the facial artery and vein. At least

Table 1. Types of facial nerve branching pattern

Type	No. of specimens	Percent(%)
I	2	4.9
II	10	24.4
III	14	34.1
IV	8	19.5
V	5	12.2
VI	2	4.9
Total	41	100

Table 2. Numbers of rami of temporal branch of the facial nerve

No. of rami	No. of specimens	Percent(%)
1	2	4.9
2	14	34.2
3	24	58.5
4	1	2.4
Total	41	100
Mean	2.6	–

2 rami were identified in 40 of 41 specimens. In 22 specimens 2 mandibular rami were present, and in 17 others 3 rami were found, and the mean number of rami was 2.4 (Table 3).

The relationship between several anatomical points

The distances between the various facial anatomical points of the specimens are shown Table IV. Distances from the mandibular angle to the facial artery and vein ranged 6~15mm, and from the mandibular angle to the mandibular symphysis 21~43mm. Distances from the mandibular angle to the bifurcation of the facial nerve ranged 5~13mm, and from the external auditory orifice to the bifurcation of the facial nerve 5~11mm. Distances from the nasion to the bifurcation of the facial nerve ranged 40~65mm, and from the nasal spine to the bifurcation of the facial nerve 40~67mm.

Discussion

Normal and abnormal presentations of the facial nerve can best be understood through an awareness of its embryonic development. The main patterns of the nerve's complex course, branching pattern, and structural relationships are established during the first 3 months of prenatal life. When the crown-rump length(CRL) is 21~22mm, the facial nerve reaches the future parotid space and sends out its peripheral branches. When the CRL is in the range 28~30mm, the parotid gland anlage grows toward the point wherethe facial nerve divides into the temporal and zygomatic branches. By the time the fetus has a CRL of 38~39mm, all peripheral branches of the facial nerve are identifiable. During this period, the expressional muscles differentiate, become functional, and actively contract. Important steps in facial nerve development

Table 3. Numbers of rami of the mandibular branch of the facial nerve

No. of rami	No. of specimens	Percent(%)
1	1	2.4
2	22	53.7
3	17	41.5
4	1	2.4
Total	41	100
Mean	2.4	–

Table 4. The relationship between facial anatomical points and the facial nerve

Anatomical Distance	Average (mm)	Range (mm)
Mastoid process to the bifurcation of facial nerve	12	7~15
Mandibular angle to the facial artery and vein	10	6~15
Mandibular angle to the mandibular symphysis	35	21~43
Mandibular angle to the bifurcation of facial nerve	9	5~13
External auditory orifice to the bifurcation of facial nerve	8	5~11
Nasion to the bifurcation of facial nerve	53	40~65
Nasal spine to the bifurcation of facial nerve	51	40~67

Table 5. Comparison of major facial nerve branching by previous studies and the present study

Type	Percent(%)				
	Davis et al.[3]	Bernstein et al.[2]	Koh et al.[11]	Park et al.[16]	Present Study
I	13	9	0	6.3	4.9
II	20	9	4.4	13.5	24.4
III	28	25	21.7	33.4	34.1
IV	24	19	8.7	23.4	19.5
V	9	22	30.4	6.3	12.2
VI	6	16	34.8	17.1	4.9
Total	–	–	–	–	100

occur throughout gestation, and significantly, the nerve is not fully developed until approximately 4 years after birth[8,11].

After the facial nerve emerges from the skull through the stylomastoid foramen, the extratemporal facial nerve runs anterolaterally in the substance of the parotid gland, and across the external carotid artery. It then divides at the posterior border of the ramus of the mandible in to two primary branches : the superior (the temporofacial) and the inferior (the cervicofacial), and from which numerous offsets, in a plexiform arrangement called the pes anserinus, are distributed over the head, face, and upper part of the neck, thus innervating the superficial muscles in these regions[3,13,14,17]. Morever, the patterns of this branching are extremely variable.

The classification of the peripheral distribution of the facial nerve is based on the type and number of anastomoses between the peripheral branches. Davis et al.[3] proposed that the patterns of branching of the facial nerve can be described as 6 types, and found in their series that the types accounted for the following percentages : type I, 18%; type II, 20%; type III, 28%; type IV, 24%; type V, 9%; and type VI, 6%, and found that types III and IV were most common and types II, III and IVmade up 72% of all. In the present study, types II, III and IV together represent almost 80% of the study specimens. Although the number of our specimens was smaller than that examined by the Davis group, our sample group was found to contain significantly larger numbers of types II and III. Type I, a classical textbook pattern, was found to be one of the least common patterns. Compared to previous adult cadaver dissection studies[2,3,11,16], there was no significant difference in the percentages of the types between the subjects in the present study, although some differences were noted in three uncommon types (Table 5).

Various surface landmarks are currently used to identify the temporal branches of the facial nerve. In the adult cadaver, the temporal branch is said to run between the lower aspect of the earlobe and the lateral edge of the eyebrow[2,7]. In our specimens, there were usually three rami that extended from the temporal branch of the facial nerve, which crossed the zygomatic arch. These rami were evenly distributed, with the posterior-most ramus always anterior to the superficial temporal vessels. Surgical dissection must, therefore, be undertaken behind the superficial temporal vessels to avoid injuring the nerve.

Variations in the anatomy of the marginal mandibular branch have been stressed during operation. Dingman and Grabb[4] presented an excellent study on the mandibular ramus of the facial nerve, based on the dissection of 100 facial halves. They found that posterior to the facial artery, the mandibular ramus ran above the inferior border of the mandible in 81% of their specimens. In the other 19%, the nerve or one or more of its branches ran in an arc, the lowest point of which was 1cm or less below the inferior border of the mandible. Anterior to the facial artery, all of the branches of the mandibular rami were above the inferior border of the mandible[4]. In adults, the mandibular branches of the facial nerve are below the angle of the mandible, and, at the point where these nerves cross the facial artery and vein, most branches are below the inferior margin of the mandible[1,15,18]. In the newborn and infant, the marginal mandibular nerve is vulnerable to injury because it lies very superficially as it courses over the mandible. This is in contrast to the location of this branch in the adult[18]. In the present study, the marginal mandibular branches were at or above the inferior border of the mandible where these branches crossed the facial artery and vein.

Infants and smaller children are further characterized from adults by the surface anatomy of the facial nerve. For the smaller the children, the lower is the amount of subcutaneous tissue fat and the closer the facial nerve is to the skin, and if the surgeon does not identify the branches of the nerve, they may be inadvertently cut. At birth, the mastoid process is absent, and the tympanic ring narrow. The nerve assumes a deeper and more protected position between 2 and 4 years of age as the tympanic ring enlarges and the mastoid process forms[12]. Thus, in the newborn and until 4 years of age, the facial nerve lies just under the skin as it exits the temporal bone and is quite vulnerable to injury. In the newborn, the stylomastoid foramen is at a high level with the facial nerve, emerging at the level of the floor of the mastoid antrum. With the growth of the squamosal portion of the mastoid, the facial canal is displaced downward while adhering to the styloid process. The position of the facial nerve in the newborn must be kept in mind whenever surgery is performed in this area[17]. In addition, the mastoid portion of the facial nerve lies in the bone that develops postnatally and shows significant increases in length with increasing age. This growth is the reason why some investigators have emphasized that because the stylomastoid foramen is located higher in infants, surgeon must be careful not to damage the facial nerve during surgery of the ear and parotid gland[6].

Conclusion

This study was based on the cadaveric dissections of the Korean fetus and stillborn infant, and described anatomical variations of the peripheral branches of the facial nerve that pose a importance in a number of surgical procedure.

The branching patterns were classified into six types : the frequencies of occurrence were : type I, 4.9%; type II, 24.4%; type III, 34.1%; type IV, 19.5%; type V, 12.2%; and type VI, 4.9%. Types II, III and IV together accounted for almost 80% of the specimens. Compared to previous adult and western stillborn fetus cadaveric studies, there was no significant difference in the percentage of the types between the subjects in the present study, similar pattern and anatomic distribution.

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Commentary

This article describes precise anatomy of facial nerve of Korean fetuses and stillborn infants. As authors mentioned in this article, I could not find out differences between adults and these specimens. First of all, this article is so similar to "A Morphological Study......." by Park IY, Lee ME in 1977. Moreover, branching patterns of facial nerves are nearly same as previou studies and several distances from bony landmarks to facial nerve were not compared to those of adults.

Despite of similar results to previous studies, authors demonstrated characteristics of facial nerves in these cadaveric specimens by fine dissection. At birth, tympanic ring and mastoid process have not been grown enough, facial nerve and its branches are more superficially located and so, quite vulnerable to injury.

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