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Histomorphometric Characteristics of the Facial Nerve

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Abstract : With the development of microsurgery, autogenous nerve grafting is being used widely in the treatment of the injured facial nerve. To use a donor graft for repair of the facial nerve, fascicular area and fascicular number should be considered in the selection of the donor site. This study demonstrated a detailed morphologic description of the facial nerve, including a microscopic assessment of nerve size and shape, and fascicular number and diameters.

40 embalmed hemi-sectioned head specimens from Korean adult cadavers were dissected to identify the facial nerve branches and nerve samples for histologic examination were cut from the anterior margin of the parotid gland.

At the border of the parotid gland, the facial nerve specimens were found to have an average of 11 branches (ranging from 8 to 16). The branches were distributed among the five distinct branches, the buccal branch had the greatest number of branches (3.47), and the zygomatic branch had the largest diameters (0.93 mm). The number of fascicles varied from one to 9 over the course of the nerve, the trunk had the greatest number of fascicles (4.36), and averages indicated a tendency for fascicular numbers to decrease distally, from trunk (4.36) to upper division (3.72) to lower division (3.60) to marginal mandibular branch (2.37). The total fascicular area was averaging 2.72 mm^2, 1.88 mm^2, and 1.04 mm^2 at trunk, upper division, and lower division, respectively. However no significant differences of the fascicular diameter could be shown between five branches.

This results of detailed facial nerve microanatomy should help in the treatment of the injured facial nerve.

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Key words : Facial nerve, Surgical anatomy, Morphometry, Korean

Introduction

The facial nerve injury causes a most disturbing deformity with functional, emotional and social consequences for the people afflicted. The complex anatomical distribution pattern of the facial nerve, its critical role in facial expressions, and the dramatic deformities resulting from a facial nerve injury have inspired numerous anatomical and speculative studies on the nerve (Bernstein and Nelson 1984, Proctor 1984, Katz and Catalano 1987, Monkhouse 1990, Ammirati et al. 1993, Gosain 1995, Lineaweaver et al. 1997, Salame et al. 2002). And accurate knowledge of the anatomy of the facial nerve is essential for the performing different surgical procedures, including parotid resection, posttraumatic exploration, nerve repairs,

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nerve transfers and nerve grafting.

With the development of microsurgery, autogenous nerve grafting is being used widely in the treatment of the injured facial nerve (Fisch and Lanser 1991, Scaramella 1996, Hadlock and Cheney 1998), and there are several suitable potential donor nerves such as hypoglossal (Manni et al. 2001), accessory (Sunder-Plassmann et al. 1970), phrenic (Perret 1967) and masseteric nerves (Fournier et al. 1997, Brenner and Schoeller 1998) for the nerve crossover, and sural (Brammer and Epker 1988), great auricular (Rayatt et al. 1998), and large cutaneous nerves (McCormick et al. 1994, Zhao et al. 1995) for the cross-face nerve grafting. These procedures raise questions about the donor nerve selection, planar positions of the peripheral facial nerve branches, and the relationships between major divisions of the facial nerve (Lineaweaver et al. 1997).

The potential for success of a nerve grafting is generally optimized when the diameters of the recipient and donor nerves are similar, when the fascicular cross-sections of these nerves are maximally opposed, usually when the number and size of the fascicles are similar, and when regenerating fibers are not diluted within the graft through anastomosis or lost through branching (Sunderland and Ray 1947, Hausamen and Schmelzeisen 1996).

The purpose of this study was to provide a detailed morphologic description of the facial nerve, including a microscopic assessment of nerve size and shape, and fascicular number and diameters.

Materials and Methods

40 embalmed hemi-sectioned head specimens from Korean adult cadavers (30 sides from 18 males, 10 sides from 7 females; mean age 62.4 years) were dissected in this study. The dissection was performed on all specimens using a surgical microscope (Carl Zeiss, Germany), while disregarding the left or right side of all specimens.

The dissections were performed in an oblique lateral position. After removing the skin and superficial fascia over the parotid area and exposing the parotid gland, the dissection was performed from the anterior margin of the parotid gland toward the temporal and mandibular ramus regions of the face. After the facial nerve branches distal to the anterior margin of the parotid gland were identified, the facial nerve branches at the border of parotid gland were tagged with ligation using a suture silk (Dafilon; Aesculap AG Co., KG) (Fig. 1A). The parotid gland was carefully removed, and all the branches were traced proximally until the main trunk was reached. A further dissection proceeded peripherally and terminated at the facial expression muscles (Fig. 1B).

After investigation about the branching patterns of the facial nerve, nerve samples for histologic examination (2-mm lengths) were cut from the trunk, upper and lower divisions, and branches at the ligated site. Each segment was fixed in 10% formalin, processed in tissue processing, and embedded in paraffin. The histologic sections were stained with hematoxylin-eosin and Luxol fast blue for light microscopy examination. The microscopic assessments including fascicular number, diameter and area were obtained using an image analyzing system (Image-Pro® Plus, ver. 4.0, Media Cybernetics, USA) after a standard calibration. The number and area of fascicles were counted in each section and those averages were reported. In the fascicular diameter, the greater and lesser diameters of each section were averaged and the reported average fascicular diameters were obtained by averaging section diameters. Very small fascicles and any apparently compartmentalized fascicles not separated by an epineurium were not counted as single fascicles.

Results

At the border of the parotid gland, the facial nerve

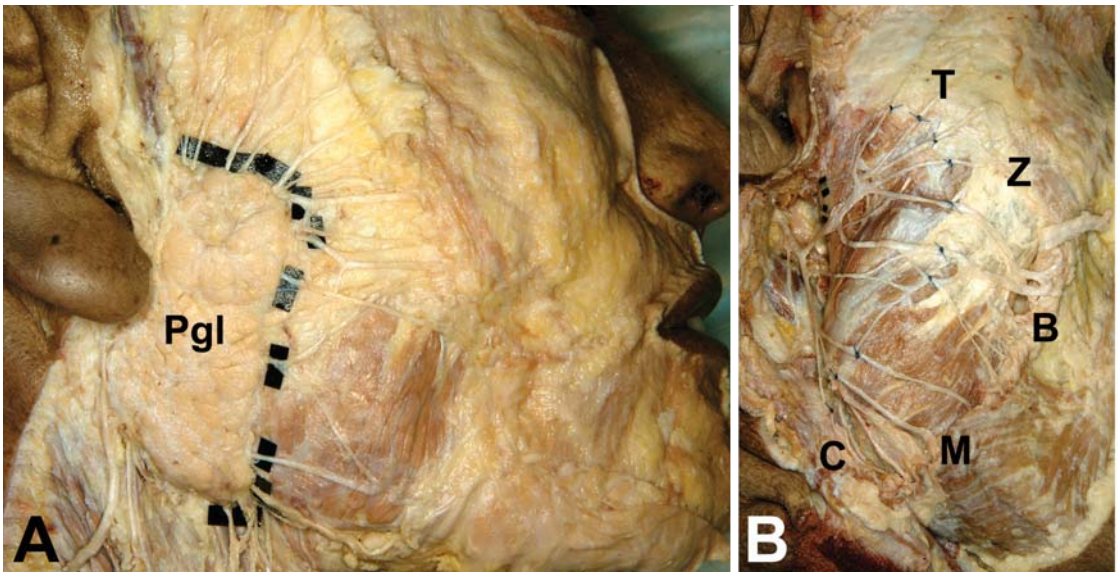

Fig. 1. The facial nerve branches at the border of the parotid gland (A), and parotid gland was removed (B). Pgl: parotid gland, T: temporal, Z: zygomatic, B: buccal, M: marginal mandibular, C: cervical branches.

Table 1. Facial nerve branches at the border of the parotid gland

Facial nerve branch	Number of branches (range)	Diameter (mm)
Temporal	2.67 (1～4)	0.75±0.32
Zygomatic	2.03 (1～4)	0.93±0.21
Buccal	3.47 (2～5)	0.81±0.27
Marginal mandibular	1.57 (1～3)	0.82±0.18
Cervical	1.27 (1～3)	0.87±0.25
Total	11 (8～16)	

Values are represented as the means±SD.

Table 2. Fascicular structure and characteristics of the facial nerve

Facial nerve branches	Fascicular number (range)	Fascicular diameter (mm)	Fascicular area (mm^2)	Total fascicular area (mm^2)
Trunk	4.36 (2～8)	0.81	0.49	2.72±0.08
Upper division	3.72 (1～9)	0.93	0.64	1.88±0.07
Lower division	3.60 (1～8)	0.82	0.56	1.04±0.07
Temporal	2.90 (1～6)	0.75	0.39	1.06±0.08
Zygomatic	2.88 (1～7)	0.93	0.37	1.31±0.06
Buccal	2.61 (1～5)	0.81	0.23	1.08±0.09
Mandibular	2.37 (1～6)	0.82	0.23	0.90±0.06
Cervical	3.00 (1～6)	0.87	0.54	1.03±0.08

Values are represented as the means±SD.

specimens were found to have an average of 11 branches (ranging from 8 to 16) (Table 1). The branches were distributed among the five distinct branches, the buccal branch had the greatest number of branches (3.47), and the zygomatic branch had the largest diameters (0.93 mm).

As can be seen in Fig. 2 and Table 2, the number of fascicles varied from one to 9 over the course of the nerve, the trunk had the greatest number of fascicles (4.36), and averages indicated a tendency for fascicular numbers to decrease distally, from trunk (4.36) to upper division (3.72) to lower division (3.60) to marginal mandibular branch (2.37). The total fascicular area was averaging 2.72 mm^2, 1.88 mm^2, and 1.04 mm^2 at trunk, upper division, and lower division, respectively. However no significant differences of the fascicular diameter could be shown between five branches.

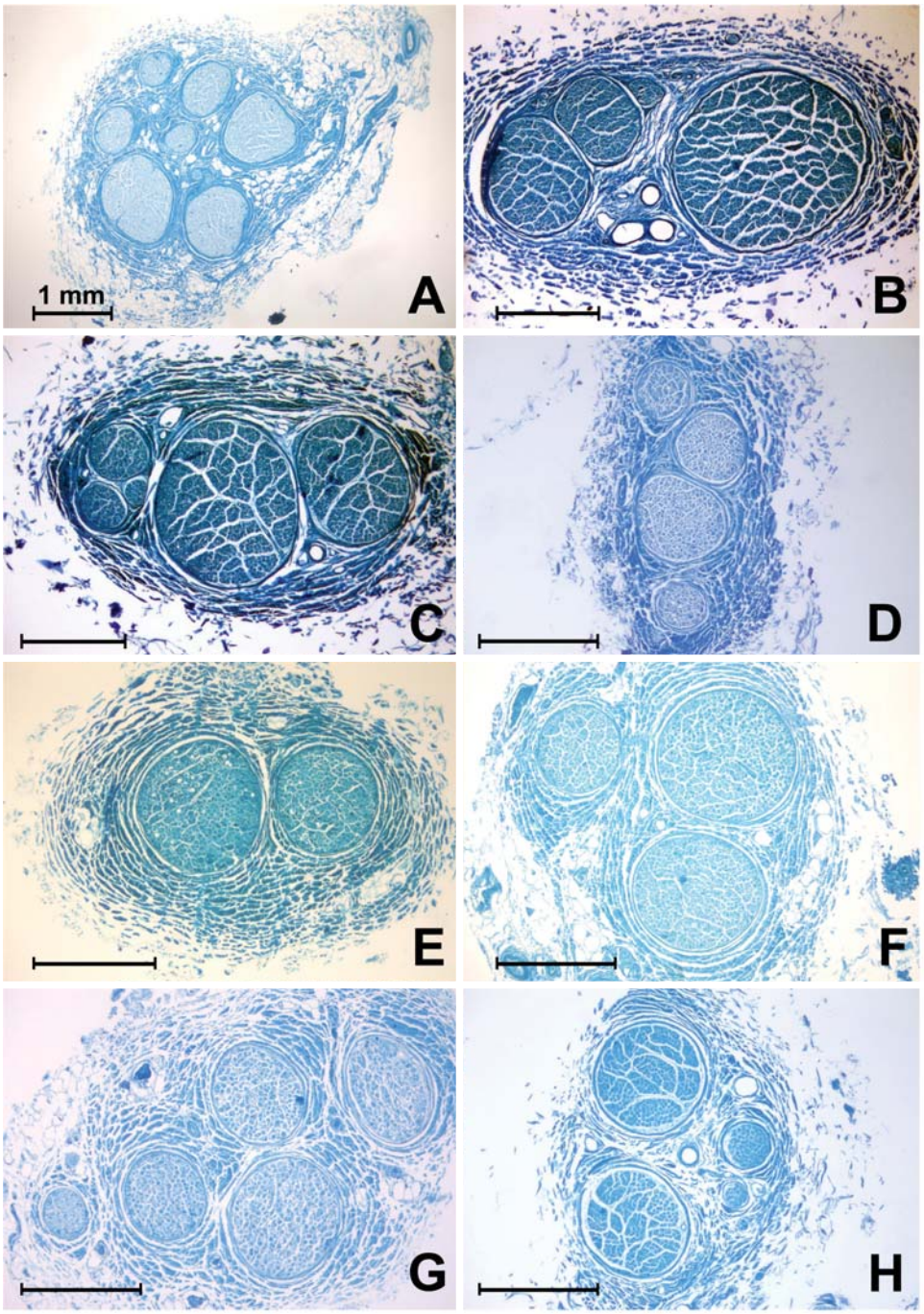

Fig. 2. Histologic sections of the facial nerve branches showing the fascicular pattern. Facial nerve trunk (A), upper division (B), lower division (C), temporal (D), zygomatic (E), buccal (F), marginal mandibular (G), and cervical (H) branches. Luxol fast blue staining. Scale bars=1 mm.

Discussion

With the development of microsurgical techniques such as cross-face nerve grafting and autogenous free nerve grafting, it is possible today to fully restore original shape and function of the facial nerve. These procedures raise questions about donor nerve selection, planar positions of peripheral facial nerve branches, and the relationships between major divisions of the facial nerve (Lineaweaver et al. 1997). The selection of a donor site for interpositional nerve grafting is determined by multiple factors, including correlation of the size between the recipient nerve and the donor, compatibility of neural functions (sensory, motor, or mixed), relative ease of graft procurement, and the degree of associated donor site morbidity (MacKinnon et al. 1989). Above all, the micro-anatomical similarity between the recipient and donor nerve is thought to be important in nerve repair (Svane et al. 1986). Severe mismatching of the fascicular number and arrangement between the graft and recipient nerve can result in inadequate axonal regeneration (Hausamen et al. 1974). Orgel (1984) and Svane et al. (1986) suggested that maximum nerve regeneration is possible only with maximum distal and proximal approximation of nerve fascicles. Therefore, when it is necessary to use a donor graft for repair of the facial nerve, fascicular area and fascicular number should be considered in the selection of the donor site. This study demonstrated fascicular characteristics of the facial nerve of Korean, and these findings may have an influence on the quality of the facial nerve graft repair.

Although individual variations among nerves most likely exist, we disregarded the differences between the sex, age, or weight in this study. However, Fujii and Goto (1989) suggested that the aging process of the facial nerve produced no decrease connected with particular sizes of nerve fibers. It seems reasonable to conclude that the number of facial nerve fibers decreases slightly with age, but there is no evidence that the axonal area or the circularity ratio of the axon decreases with age. Jacobs et al. (1996) reported that no correlation with age was identified in the assessment of nerve fiber regeneration, although, in experimental studies (Tanaka et al. 1992, Campbell and Pomeranz 1993), nerve fiber regeneration was found to be less efficient in older animals.

Interfascicular repair requires that the surgeon be intimately familiar with the fascicular anatomy of the facial nerve. Full description of the facial nerve including its anatomic course and histological analysis confirms the utility of many nerves as a donor nerve for the facial nerve grafting. And careful attention to the anatomic and histological survey presented will allow safe identification and preservation of this important structure.

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얼굴신경의 조직계측학적 특성

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간추림 : 얼굴신경의 손상은 기능적인 장애뿐 아니라 심미적, 정신적으로도 심한 문제를 야기하기 때문에 얼굴신경의 결손 치료를 위한 다양한 자가신경의 이식술(autonerve graft)이 시행되고 있다. 자가신경이식의 성공을 위해서는 신경의 절단면적, 신경다발(fascicle)의 개수 등 얼굴신경의 미세해부학적 구조에 대하여 명확히 알고 있어야 한다. 그러나 한국인의 얼굴신경에 대한 미세해부학적 연구가 없다. 따라서 이 연구의 목적은 한국인 얼굴신경가지들의 각 부위에 대한 미세해부학적 구조를 확인하는데 있다.

한국인 시신의 머리 40쪽을 해부하여 얼굴신경을 노출시키고, 각 신경가지를 분류하였다. 신경가지의 수와 직경을 계측한 후, 조직염색을 하여 부위에 따른 신경다발의 수, 면적 등을 계측하였다.

얼굴신경가지의 개수는 볼가지가 평균 3.47개로 가장 많았으며, 관자가지 2.67개, 광대가지 2.03개, 턱모서리가지 1.57개, 목가지 1.27개였다. 얼굴신경가지의 평균직경은 광대가지가 0.93 mm로 가장 두꺼웠으며, 관자가지가 0.75 mm로 가장 얇았다. 신경다발의 수는 하나부터 아홉 개까지 다양하였으며, 얼굴신경줄기의 신경다발이 평균 4.36개로 가장 많고, 먼 곳으로 갈수록 적어지는 양상을 보였다. 신경다발의 총면적은 각각 얼굴신경줄기에서 2.72 mm^2, 관자얼굴가지에서 1.88 mm^2, 목얼굴가지에서 1.04 mm^2로 계측되었다.

얼굴신경의 미세해부학적 구조에 대한 이 연구결과는 얼굴신경의 결손 치료를 위한 기초자료로 활용할 수 있을 것이다.

찾아보기 낱말 : 얼굴신경, 수술해부, 형태계측, 한국인

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