The Journal of Korean Academy of Maxillofacial
Plastic and Reconstructive Surgery
Vol. 13, No1 : 30-36, 1991

MICRONEUROSURGICAL RECONSTRUCTION OF THE ORAL AND MAXILLOFACIAL REGION USING THE SURAL NERVE

-HISTOLOGIC STUDY-

Myung-Jin Kim, D.D.S., M.S.D., Ph.D., Byeong-Rin Kim. D.D.S., M.S.D.

Dept. of Oral and Maxillofacial Surgery, College of Dentistry, Seoul National University

Various nerves from many areas of the body can be used as a donor of autogenous nerve graft in the microneurosurgical repair of the oral and maxillofacial region.

In the grafting procedure of nerve repair, the best results will be achieved with a maximum approximation of fascicular surface at both the porximal and the distal stumps.

Therefore, appropriate selection of donor nerve will bring out the best results.

The sural nerve has been used as one of the most popular donor nerve in the microneurosurgical repair of the oral and maxillofacial region.

The authors examined the fascicular characteristics of the human sural nerve microscopically and compare this results with our previous report of the greater auricular nerve and that of the inferior alveolar nerve.

key words : Microneurosurgical repair, Sural nerve, Fascicular characteristics

I. INTRODUCTION

Nerves from many areas of the body may be employed as a donor nerve in the microneurosurgical repair of the oral and maxillofacial region. In nerve grafting the best results will be achieved with a donor nerve that has similar cross-sectional fascicular area and fascicular number and that allows maximum fascicular area to be approximated at both the proximal and the distal stumps. Therefore, selection of appropriate donor nerve will bring out best results[1,2].

The sural nerve has been one of the most popular donor in the microneurosurgical repair of the oral and maxilloacial region. It provides sufficient length as donor nerve. So large nerve defects can be adequately repaired by the sural nerve[3,4,5]. The purpose of the study is to determine the fascicular characteristics of the human sural nerve and to compare with that of the greater auricular nerve[6] and to have a reference in the selection of a donor nerve for reconstruction of nerve defects in the oral and maxillofacial region.

II. MATERIALS AND METHODS

Ten pieces of the sural nerve were harvested from fresh cadavers in the full length as possible. The available length were recorded for each nerve(table 1). A silk suture tag was placed at the distal end of each nerve to aid in orientation. The nerves were divided into three groups by the location. The proximal portion was defined as just distal portion of the site communicating with the tibial nerve, the middle portion defined as just proximal portion of the site communicating with peroneal communicating branch, and the distal portion defined as the site of the sural

This work was funded by the special research program of Seoul National University Hospital, Seoul, Korea in 1990.

nerve being 1cm above the superior border of the lateral malleolus(Fig. 1)[7].

The nerves were embedded in the paraffin and stained with hematoxylin and eosin, after thin cross-section and then magnified to 40X under the light microscope and photographed with color slide film. The nerve slides were projected onto the same surface area grid so that the cross-sectional fascicular area and total cross-sectional nerve area could be calculated for the proximal, middle, distal portion of the ten nerves. Small isolated fascicle and small fascicle adjacent to large fascicle without septa were excluded in calculation. Means and standard deviations were calculated for each portion of the nerves.

Table 1. Available Length

Specimen	Length(cm)
N 1	38.2
N 2	34.8
N 3	33.7
N 4	39.8
N 5	36.2
N 6	30.5
N 7	38.1
N 8	36.4
N 9	33.2
N10	34.3
Mean	35.5

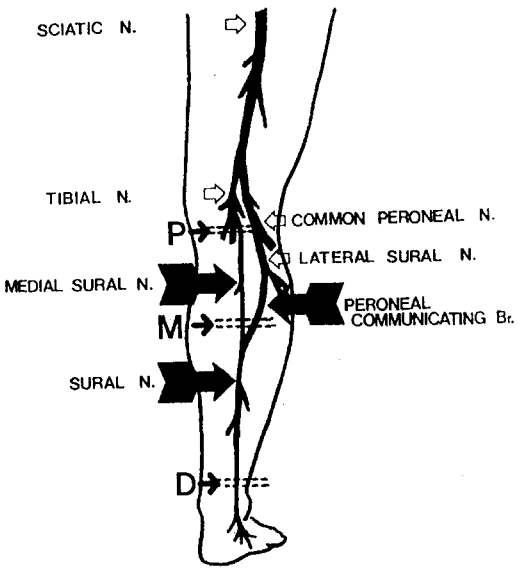

Fig. 1. Sural Nerve
=== sites from which histological specimens were taken.
P ; Proximal, M : Middle, D ; Distal.

III. RESULTS

The histologic sections showed that the sural nerve was polyfascicular in ten of ten cases at the proximal portion, in nine of ten cases at the middle portion, and eight of ten cases at the distal portion(Fig. 2, Fig. 3).

The fascicles did not appear to follow any order but were in a totally random arrangement.

The mean total cross-sectional nerve area was

Fig. 2. Tyical polyfascicular pattern of the sural nerve

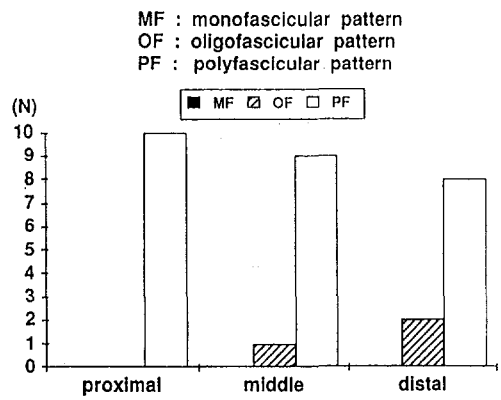

Fig. 3. Pattern of fascicles

3.83㎟(SD=1.24) at the proximal portion, 3.28㎟ (SD=1.47) at the middle portion, and 4.65㎟(SD= 1.90) at the distal portion.

There was a significant decrease in fascicular number as the distal portion of the nerve was approached. The mean number of the fascicles was 7.67(SD=1. 37) at the proximal portion, 6.17(SD=3.19) at the middle portion, and 3.83(SD=1.33) at the distal portion.

The mean total cross-sectional fascicular area was 0.80㎟(SD=0.26) at the proximal portion, 0.79㎟ (SD=0.22) at the middle portion, and 1.23㎟(SD= 0.75) at the distal portion.

The ratio of the mean total cross-sectional fascicular area to the mean total cross-sectional nerve area (TFA/TNA) was 0.22(SD=0.05) at the proximal portion, 0.27(SD=0.10) at the middle portion, and 0.25(SD=0.06) at the distal portion.

The mean individual fascicular area(TFA/FN) was 0.11(SD=0.05) at the proximal portion, 0.14(SD= 0.04) at the middle portion, and 0.34(SD=0.19) at the distal portion(Fig. 4).

It was observed that the perineurial vascular networks existed but not so prominent.

Ⅳ. DISCUSSION

The authours had reported the fascicular characteristics of the human greater auricular nerve and of the human inferior alveolar nerve[8]. So,We discuss the results of the human sural nerve comparing with our previous reports of the greater auricular nerve and of the inferior alveolar nerve.

As for the fascicular pattern, the inferior alveolar nerve was polyfascicular pattern[5], the greater auricular nerve shows mixed fascicular pattern[6]. In this study, the sural nerve was polyfascicular in the majority(Fig. 3).

As for the maximum available length, the greater auricular nerve was 8-10cm[9] and the sural nerve was 35.5cm(SD=3.32) in this study. Therefore the sural nerve is suitable for the reconstruction of large

TNA : Total cross-sectional nerve area
FN : Fascicular number
TFA : Total cross-sectional fascicular area

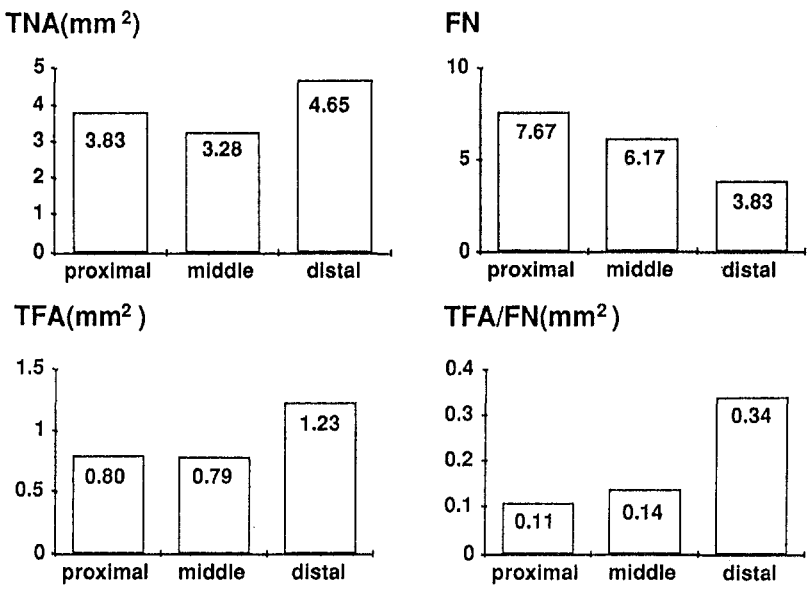

Fig. 4. Fascicular characteristics

defect of the nerve. The available length from just distal portion of the site communicating with communicating branch of the lateral sural nerve to the area 1cm above the superior border of the lateral malleolus was about 15cm. It is enough length for reconstructing the inferior alveolar nerve or spinal accessory nerve or facial nerve in unilateral defect.

As for the mean total cross-sectional nerve area, the inferior alveolar nerve was 4.23-5.05㎟ and the greater auricular nerve was 2.34-2.55㎟ [6]. In this study, the sural nerve was 3.28-4.65㎟ , about 1.6 times of the greater auricular nerve(Fig. 5). The sural nerve had the largest cross-sectional area(4.65 ㎟) at the distal portion. So the part from the middle portion to the distal portion of the sural nerve may be donor of choice in repair of the inferior alveolar nerve. As for the mean fascicular number, the inferior alveolar nerve was 5.7-8.1[8] and the greater auricular nerve was 5.0-9.7[6]. The sural nerve was 3.83-7.67(Fig. 6). The sural nerve had the smallest fascicular number(3.83) at the distal portion.

As for the mean total cross-sectional fascicular area, the inferior alveolar nerve was 1.2-1.7㎟ [5] and the greater auricular nerve was 0.73-0.83㎟ [6]. In this study, the sural nerve was 0.79-1.23㎟(Fig. 7). Considering fascicular structure, size and number, the Sural nerve, especially the distal part, is better than the greater auricular nerve in reconstruction of the inferior alveolar nerve.

In consideration of the size of the microsuture needle[10], It is recommended to use the group fascicular suture method in the repair of the inferior alveolar nerve using the greater auricular nerve or the sural nerve. If the interfascicular suture method used, the stitches might damage each fascicle and make obstructions of the passage of regenerating nerve fibers[11,12,13,14,15].

In the repair of the nerve, the role of nerve graft is to act as a tunnel through which the sprouting axons from the proximal stump may reach the distal stump. When the sprouts of regenerating nerve fibers reach the distal segment and find their way into the neurilemmal tubes which act as conduits, their rate

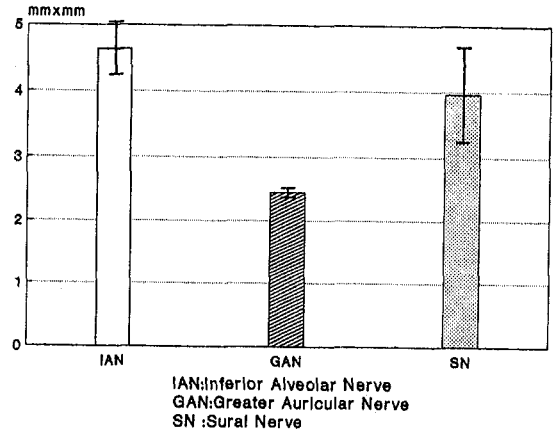

Fig. 5. Mean Total cross-sectional Nerve Area

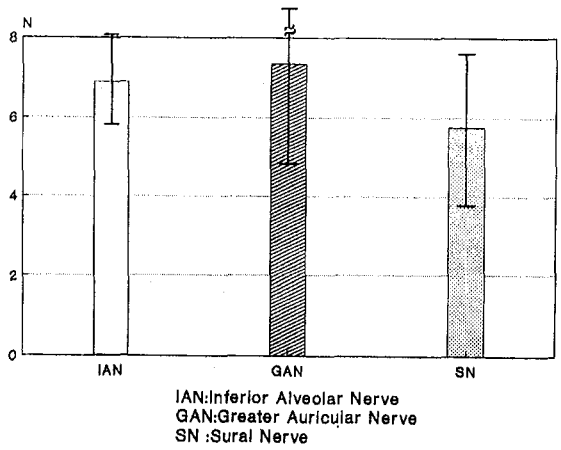

Fig. 6. Mean Fascicular Number

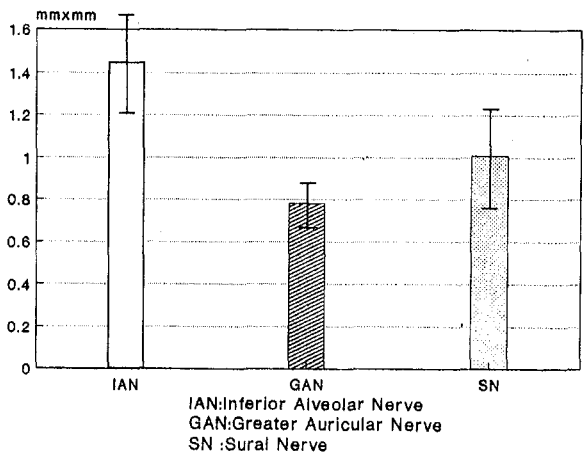

Fig. 7. Mean Total cross-sectional Fascicular Area

Fig. 8. The sural nerve was harvested from fresh cadavers in the full length.

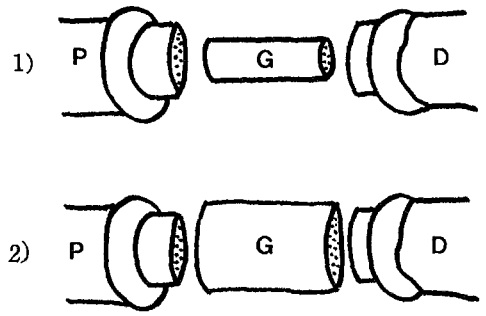

Fig. 9. The importance of cross-sectional size of the graft. Many of sprouting axons of the proximal stump would be lost in the smaller graft(1), but be collected in the larger graft(2) at the proximal junction.

of growth is considerably accelerated. The rate of regeneration is approximately 1 mm/day at the late period of nerve regeneration[16]. So the grafts might play the same role not only in the repair of the sensory nerve but in the repair of the motor nerve. Grafts that are larger than the nerve to be repaired would have the advantage of being better able to collect the sprouting axons of the proximal stump, but when the smaller distal stump is reached many of sprouting axons would be lost. Smaller donor grafts would lead to reduced numbers of axons at the proximal junction [2] . So the size of the cross-sectional nerve area might play a important role in the process of nerve repair.

As for the perineurial vascular networks, the greater auricular nerve[6] and the sural nerve have some vascularity in the perineurium and the inferior alveolar nerve has rich vascularity in the perineurium[8]. It is advisable to retain a dense vascular net around the graft and, recipient nerve but not on the suture site, for the purpose of achieving rapid vascularization of the graft and preventing the intermediate tissue to grow into the suture site[12].

The sural nerve is an excellent source of nerve tissue because it is readily accessible, has several large fascicles, provides 30 to 40cm of graft material, and can be obtained with minimal donor site morbidity, which is limited to alteration of sensation and scar formation. The sensory deficit includes the lateral border of the foot, the posteroloateral part of the ankle, and the lateral edge of the sole. Although this deficit is permanent, the affected area appears to diminished with time[17,18]. Generally, the scar is well camouflaged because it is hidden by the prominence of the lateral malleolus and clothing. A potential hazard of the sural nerve harvesting is injury to the lesser saphenous vein. After harvesting of the nerve, the foot is wrapped and elevated. Ambulation is discouraged for as long as 2 weeks, which may be inconvenient[19].

The greater auricular nerve is another source of nerve tissue. Its advantages for the mandibular nerve reconstruction are its proximity to the operative field. After harvesting, there is a transient sensory deficit involivng the ear and the skin overlying the parotid gland. almost full sensation returns within 6 months. The greater auricular nerve can be used in the reconstruction of the nerve defect smaller than 8-10cm[9]. In consideration of the cross-sectional nerve area, however, the use of the greater auricular neve can be restricted. Two pieces of the greater auricular nerve should be needed in the repair of the inferior alveolar nerve for the maximal approximation of the nerve[6].

Conclusively, the sural nerve is the donor of choice in the reconstruction of large nerve defect in the oral and maxillofacial region. The inferior alveolar

nerve, the facial nerve and the accessary nerve could be reconstructed using the sural nerve.

V. CONCLUSION

The authors examined the fascicular characteristics of the human sural nerve microscopically. The fascicles of the sural nerve were in a totally random arrangement and polyfascicular pattern in the majority. The mean total cross-sectional nerve area increased as the distal portion of the sural nerve was approached and it was 4.65㎟(SD=1.90) at distal portion. The maximal available length of the sural nerve as donor was 35.5mm²(SD=3.32). The available length from just distal portion of the site communicating with communicating bracnch of the lateral sural nerve to the distal portion was about 15cm.

In conclusion, the sural nerve is the donor of choice in the reconstruction of large nerve defects and multiple nerve defects. The inferior alveolar nerve, the facial nerve and the accessory nerve could be reconstructed using the sural nerve during oncologic ablative surgery and reconstructive surgery after trauma.

. Acknowledgment

The authors would like to thank the Department of Anatomy of College of Dentistry, Seoul National University, for preparation of the cadavers and for kind helpful advice.

REFERENCES

1. Mc Carthy : Plastic Surgery P. 630, Vol. 1, WB Saunders, Philadelphia, 1990.
2. T.J. Svane, L.M. Wolford, S.B. Milam, R.K. Bass : Fascicular characteristics of the human inferior alveolar nerve. J Oral Maxillofac Surg 44 : 1986.
3. S.Riediger, T.Ehrenfeld : Microsurgical Tissue Transplantation P. 190, Quintessence Publishing Co., Inc., 1989.
4. G.A. Wessberg, L.M. Wolford : Bilateral microneurosurgical reconstruction of inferior alveolar nerves via autogenous sural nerve transplantation. Oral Surg 52 : 465, 1981.
5. M.J.Kim : Microneurosurgical repair of the cut inferior alveolar nerve in rabbits. Journal of Korean Academy of Oral and Maxillofacial surgery 11 : 203, 1985.
6. M.J.KIM, B.R. KIM : Microneurosurgical reconstruction of the inferior alveolar nerve using the greater auricular neve. Histologic study. Korean J Oral Maxillofac Surg 16 : 1, 1990.
7. F.H.Netter : The Ciba Collection of Medical Illustrations. P.125, Vol. 1 CIBA, West Caldwell, 1983.
8. M.J.KIM, J.H.JEON : Fascicular Characteristics of the human inferior alveolar nerve. Korean J Oral Maxillofac Surg 13 : 179, 1987.
9. H.Noma, T.Kakizawa, G.Yaqmane, K. Sasaki : Repair of the mandibular nerve by autogenous grafting after partial resection of the mandible. J Oral Maxillofac Surg 44 : 31, 1986.
10. S.Lee : Experimental Microsurgery. P.21, IGAKU-SHOIN, New York, 1987.
11. M.G.Orger and J.K.Terzis : Epineural vs perineural repair. Plast Reconstr Surg 60 : 80, 1977.
12. Y.Yamazaki and H.Noma : Comparison of suture methods and materials in experimental inferior alveolar nerve grafting. J Oral Maxillofac Surg 41 : 34, 1983.
13. Robert W.Rand : Microneurosurgery. P.415, 2nd Ed. C.V.Mosby Co., Saint Rouis, 1978.
14. M.J.Kim : An experimental study of degeneration and regeneration after autogenous grafting of the inferior alveolar nerve in rabbits : Comparison of microsurgical suture methods. Journal of Korean Dental Association 23 : 783, 1985.
15. M.J.Kim, et al : A clinical study on the functional repair of inferior alveolar nerve by autogenous nerve graft(report of 6 cases). Journal of Korean Academy of Oral and Maxillofacial Surgery 13 : 187, 1987.
16. Peter G. Mozsary : Letter to the editor, Inferior alveolar and lingual nerve injuries : regeneration

or operation. J Oral Maxillofac Surg 45 : 204, 286, 1987.
17. H.L.Hill, L.D.Vasconez, M.J. Jurkewicz : Method for obtaining a sural nerve graft. Plast Reconstr Surg 61 : 177, 1978.
18. T.R.Fisher, P.Cox : The sural nerve as autogenous nerve grafts. J Bone Joint Surg 56 : 571, 1974.
19. T.B. Dodson, L.B. Kaban : Donor site morbidity. Oral and Maxillofacial Surgery. Clinics of North America. Vol. 2 : 489, 1990.

국문초록

비복신경을 이용한 구강 및 악안면 영역의 신경재건
-해부학적 특성에 관한 연구-

서울대학교 치과대학 악안면구강외과학교실
김명진 · 김병린

본 연구는 구강 및 악안면 영역에서의 미세 신경 재건술에 대한 일련의 연구의 하나로서 구강 및 악안면 영역의 신경 결손부를 재건할 경우 가장 많이 이용되는 비복신경에 대한 해부학적 특성을 조사하여 이식 신경 선택시에 도움이 되도록 하고자 본 연구를 시행하였다.

연구 대상은 사체에서 채취한 10편의 비복 신경으로 하였고 각 신경편의 길이 측정후 신경편의 근심부, 중심부, 원심부에 대하여 신경의 평균 총단면적, 신경속의 평균 숫자, 신경속의 평균 총단면적 등을 측정하였고 신경속의 주행 양태 및 신경 주위 외막의 미세혈관 분포를 관찰하였다.

연구결과, 채취 가능한 비복 신경의 길이는 평균 35.5cm 이었고 신경의 평균 총단면적은 근심부, 중심부, 원심부에서 부위별로 각각 3.83mm^2, 3.28mm^2, 4.65mm^{2}이고, 신경속의 평균 총단면적은 부위별로 각각 0.80mm^2, 0.79mm^2. 1.23mm^{2}이었다. 신경속의 평균 숫자는 부위별로 각각 7.67, 6.17, 3.83개 이었고 주로 복신경속 모양(polyfascicular pattern)의 구조를 보이며, 신경속의 주행양태는 불규칙하였고 신경 주위 외막의 미세혈관 분포는 존재하였지만 미약하였다.

신경이식 수술후 바람직한 결과를 얻기 위해서는 신경의 총단면적이 비슷하거나 크며 비슷한 신경속의 숫자를 지니는 유사한 해부학적 구조를 가진 이식신경을 선택하여 최대로 신경속간 접합이 될 수 있도록 해야하는데 비복 신경은 신경속의 해부학적 특성, 크기, 숫자로 보아 하치조신경, 안면신경, 부신경등 악안면부의 신경이식에 널리 쓰일 수 있는 이식 신경으로 사료되며 특히 원심부에서 채취가능한 약 15cm 가량의 비복신경은 하치조 신경의 신경속 구조와 매우 유사하며 하치조신경 결손부의 이식 신경으로 적합한 것으로 사료된다.