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Original Article

Anatomic and Histological Study of Lingual Nerve and Its Clinical Implications

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Abstract

Although the risk of injuring the lingual nerve in the mandibular molar area during dental treatment is high, it can be repaired by nerve grafting. However, from the perspective of clinical dentistry, the pathway and histomorphometric characteristics of this nerve remain to be documented in detail. The purpose of the present study was to morphologically elucidate the pathway of the lingual nerve to clarify its significance in a clinical setting. A histomorphometric analysis was also performed in consideration of nerve grafting. The vertical distance between the occlusal plane and the superior margin of the lingual nerve showed a gradual decrease from the premolar toward the distal molar area. This suggests that the risk of injuring the lingual nerve increases gradually toward the distal area. The average total fascicular area of the lingual nerve was $1.90\,mm^2$, which was larger than that of the sural nerve. It is the first-choice donor nerve for grafting. Therefore, even though the total fascicular area of the donor nerve is a little smaller than that of the recipient nerve, nerve grafting should be successful.

Key words: Lingual nerve — Third molar region — Dental treatment — Anatomy — Histomorphometric analysis

Introduction

The mandibular nerve originates in the trigeminal ganglion, 10–20 mm below which it separates into the inferior alveolar and lingual nerves. The lingual nerve joins the chorda tympani, a branch of the facial nerve, on the external surface of the medial pterygoid muscle. The chorda tympani contains taste nerve fibers and salivary secretion-

related parasympathetic nerve fibers. It runs inferiorly along the external surface of the medial pterygoid muscle, changes its course near the posterior extremity of the mylohyoid line, and runs beneath the sublingual mucosa on the lingual side of the most posterior molar[8]. The lingual nerve is considered to supply the mucous membrane of the anterior two thirds of the tongue, the floor and side wall of the mouth, and the mandibular gums. It also carries nerve fibers that are not part of the mandibular nerve, including the chorda tympani nerve of the facial nerve, which provides special sensation (taste) to the anterior two thirds of the tongue.

Many reports have suggested that, since the lingual nerve runs along the internal surface of the mandibular bone in the anterior margin of the medial pterygoid muscle, there is a high risk of injuring the nerve in the mandibular molar area during dental treatment[6–9,12,17–20]. Enormous variation in the pathway of the lingual nerve, especially in the area of the third molar, has been reported. One such variation is that the lingual nerve sometimes traverses the retromolar pad area between the back of the last molar and the anterior edge of the ascending ramus. In particular, the possibility of lingual nerve paralysis increases during mandibular foramen conduction anesthesia[16], impacted mandibular wisdom tooth extraction[7,18], endosseous implant surgery, and periodontal surgery[4]. However, the risk of injury to the lingual nerve during gingival incision was not considered in these earlier studies.

If the lingual nerve is injured during dental treatment, it can be rectified by direct epineurial repair or indirect (graft) neurorrhaphy. It has been reported that graft repair of the lingual nerve provides superior long-term objective and subjective outcomes in comparison with direct repair[14]. The most appropriate autogenous graft for the lingual nerve is the sural nerve, which is similar in diameter and fascicular pattern[2]. The latter has been used widely as a donor nerve for autogenous graft procedures. Its popularity in this regard is attributable to the fact that it is long, composed entirely of sensory fibers, supplies a relatively unimportant dermatome, and is easily located[22].

Recently, the histology of the lingual nerve has been widely discussed. The lingual nerve is composed of 5 or 6 fascicles arranged in a circular manner around a central arteriole[15]. Smith and Harn have described the microanatomy of the lingual nerve in the area of the third molar, pointing out two patterns of organization of the nerve cell bodies: isolated nerve cell bodies and ganglion-like clusters[21]. However, the histomorphometric characteristics of the lingual nerve were not explored in the context of nerve grafting.

Bearing in mind the risk of injury to the lingual nerve on incision of the gingiva, the purpose of the present study was to morphologically elucidate its pathway to clarify its significance in a clinical setting. Additionally, an attempt was also made to histomorphometrically measure the lingual nerve in the area of the third molar in consideration of the issue of nerve grafting.

Materials and Methods

This study was performed using 10 cadavers for anatomical practice preserved at the Department of Anatomy, Tokyo Dental College. The occlusal relationship was retained and over 24 teeth remained in the maxilla and mandible in all samples.

An incision was made that included the bilateral posterior margins of the mandibular bone and superior margin of the hyoid bone. The inferior alveolar nerve, hyoid bone, and suprahyoid muscle group were then dissected en bloc together with the mandibular bone. Furthermore, the mucosa and temporal, lateral pterygoid, and masseter muscles were removed from the external surface side. Next, the mandibular bone was sectioned in the median area, and the sublingual gland, submandibular gland, and medial pterygoid muscle removed from the internal surface side. The lingual nerve was carefully abraded without changing the relationship between
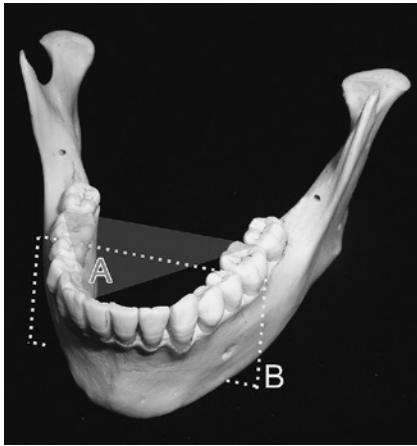
Fig. 1 Reference planes

A: Plane connecting incisal point and disto-buccal cusp of bilateral first molars (occlusal plane).
B: Plane perpendicular to occlusal plane, containing line connecting mesial contact point of bilateral first molars.
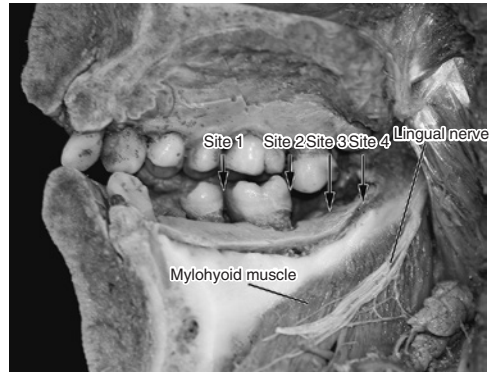

Fig. 2 Vertical distance on reference plane B between reference plane A and superior margin of lingual nerve was measured

Measurement sites comprised mandibular second premolar (site 1), first molar (site 2), second molar (site 3), and third molar (site 4).

the nerve and surrounding tissue. After dissecting the lingual nerve, the mylohyoid muscle, tongue, and lingual nerve were observed macroscopically from the internal side.

Measurement was performed by establishing the following: reference plane A, connecting the incisal point and disto-buccal cusp of the bilateral first molars (occlusal plane 1); and reference plane B, perpendicular to the occlusal plane, containing a line connecting the mesial contact point of the bilateral measurement teeth (Fig. 1).

The vertical distance on reference plane B between reference plane A and the superior margin of the lingual nerve was measured (Fig. 2). Measurement sites were the mandibular second premolar (site 1), first molar (site 2), second molar (site 3), and third molar (site 4) (Fig. 2). However, there were cases in which the mandibular second and third molars were lost. In such cases, points based on the mean of the size of the tooth were measured instead[9].

Sections were prepared for histomorphometric analysis by first harvesting the lingual nerve from 4 specimens. These specimens were post-fixed for 72 hr with 4% paraformaldehyde and then embedded in paraffin wax. Transverse sections 10 μm in thickness were mounted on glass slides and then stained with Masson trichrome. Histologic observations were performed with the aid of a light microscope and photographs obtained. These histological photographs were used for subsequent morphometric analysis. The areas of the lingual nerve were measured according to tooth region, that is to say, the third molar (site 4) (Fig. 2). The number of fascicles, total fascicular area, and nerve area of the lingual nerve were determined for the area of the third molar using the Image J program (developed at the US National Institutes of Health and available on the internet at http://rsb. info.nih.gov/ij/).

Results

1. Distance between occlusal plane and superior margin of lingual nerve

The mean distance was 27.1 mm at site 1; 25.2 mm at site 2; 17.9 mm at site 3; and 9.3 mm at site 4. The minimum distance was 21.0 mm at site 1; 16.6 mm at site 2; 12.3 mm at site 3; and 0 mm at site 4 (Table 1). The distance between the occlusal plane and the

Table 1 Vertical distance on the reference plane B between the reference plane A and the superior margin of lingual nerve

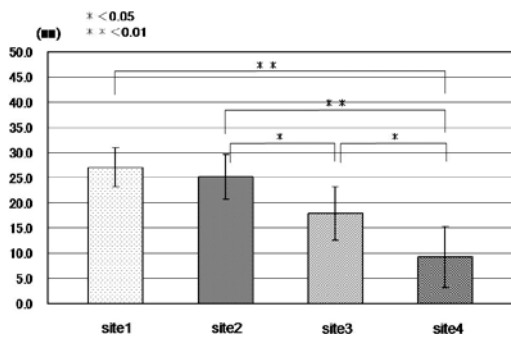|	Mean distance (mm)	Minimum distance (mm)	Maximum distance (mm)	Standard deviation (mm)
Site 1	27.1	21	30.5	± 3.36
Site 2	25.2	16.6	28.6	± 4.42
Site 3	17.9	12.3	25	± 5.26
Site 4	9.3	0	17	± 6.15

Fig. 3 Distance between occlusal plane and superior margin of lingual nerve
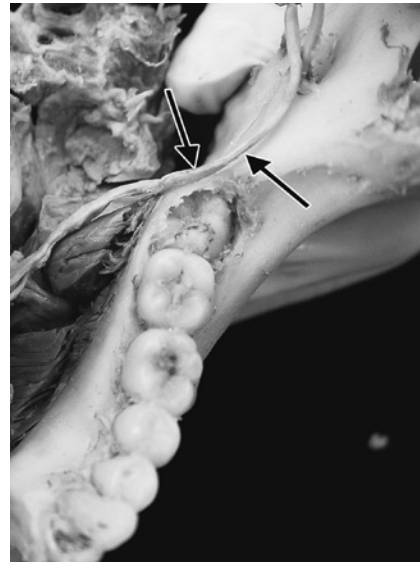

Fig. 4 Observation of pathway of lingual nerve on surface of third molar

Lingual nerve was close to distal area of third molar (arrow). It ran inferiorly along internal oblique line of mandibular bone, mildly curved in distal area of third molar, ran inferiorly on mylohyoid line, and reached lowest position in area of second molar.

superior margin of the lingual nerve showed a gradual decrease from the premolar toward distal molar sites (Fig. 3).

Differences in data were tested using Fisher's exact test (Fig. 3).

2. Observation of pathway of lingual nerve on distal surface of third molar

The course of the lingual nerve showed the following two patterns:

Type I: The nerve was located close to the area distal to the third molar. It ran inferiorly along the internal oblique line of the mandibular bone, curved mildly in the area of the third molar distal, ran inferiorly on the mylohyoid line, and reached its lowest position in the area of the second molar (44% of cases; Fig. 4).

Type II: The nerve was separated from the area distal to the third molar. It ran inferiorly along the internal oblique line of the mandibular bone, curved markedly in the area distal to the third molar, making the shape of an "S", ran inferiorly on the mylohyoid line, and reached its lowest position in the area of the second molar (56% of cases).

3. Histomorphometric analysis of lingual nerve in area of third molar

The mean of the total number of fascicles, the total fascicular area, and the nerve area were 16.25 (range, 8–22), 1.90 mm² (range, 1.65–2.00 mm²), and 5.09 mm² (range, 3.34–6.68 mm²), respectively (Table 2). The total number of fascicles and the nerve area differed among the 4 specimens. However, there was little variation in the total fascicular area. Ganglion cells were observed in 1 of the 4 specimens, where they mixed with nerve fibers in a fascicle (Fig. 5AB).

Discussion

It is indisputable that anatomical positional

Table 2 The metric value of the histologic findings of great auricular nerve

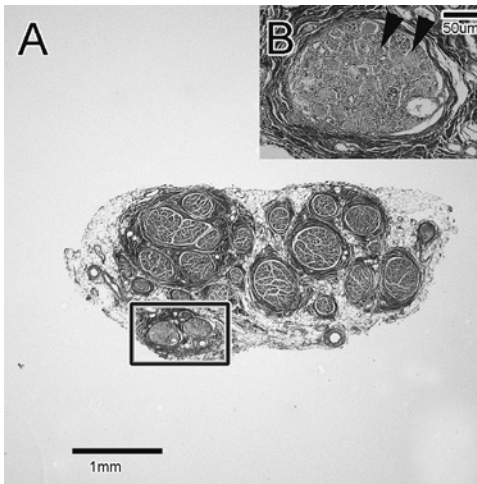| Specimen No.	Total fascicular number	Total fascicular area (mm²)	Nerve area (mm²)
68	22	1.95	6.63
74	21	2.00	6.68
1,998	14	1.65	3.71
77	8	1.98	3.34
Mean ± SD	16.25 ± 6.55	1.90 ± 0.16	5.09 ± 1.81

Fig. 5 Masson trichrome-stained section showing lingual nerve

Ganglion cells (arrowhead) observed in 1 of 4 specimens (Specimen No. 74); mixing with nerve fibers in fascicle (panel B). Panel B shows higher-magnification view of square in panel A.
Bar = 1 mm (panel A), 50 μm (panel B).

relationships cannot be evaluated accurately by dental X-ray, X-ray computed tomography, magnetic resonance imaging, or ultrasonography, making it very difficult to understand the morphology of related structures before dental surgery[6,11].

The present results revealed that the vertical distance between the occlusal plane and superior margin of the lingual nerve showed a gradual decrease from the premolar area toward the molar distal area, suggesting that the risk of injuring the lingual nerve increases gradually in a distal direction. Furthermore, the vertical distance in the area distal to the third molar was 0 mm in some samples. This indicates the need to exercise care during dental treatment in order to avoid accidents, as the lingual nerve is located close to the cervical area of the molars.

In some of the samples, the lingual nerve ran on the lateral surface of impacted wisdom teeth, in which thin alveolar bone was present between the nerve and the teeth. In such cases, the lingual nerve might be injured when making a lingual incision.

A standard incision to extract an impacted mandibular wisdom tooth is basically initiated from a point slightly apart from the distal surface of the second molar between the internal and external oblique ridges, and then extended mesially to the buccal side along the cervical area of the second molar, further than the buccal groove. Thereafter, a longitudinal incision is made in an antero-inferior direction, with angulation in the inferior protuberant area below the mesio-buccal cusp. Furthermore, in cases where the tooth crown is markedly inclined in the lingual direction, it is often impacted in a comparatively shallow area. Therefore, an incision should be made only in the cervical and alveolar areas, without incising the lingual alveolar mucosa, which is thin and weak[16]. When an incision is made according to these surgical procedures, no injury to the lingual nerve will usually occur. However, lingual nerve sensory disorders may occur when inappropriate surgical manipulation is performed. The present study revealed that a longitudinal incision in the lingual direction should be made in the premolar region within 5–10 mm from the alveolar crest or interdental papillar area, and that a

longitudinal incision in the molar region carries a very high risk. When visualization of the surgical field in the molar region is required, it is important to abrade a mucoperiosteal flap, without making a sharp incision with scalpels.

Lingual nerve disorders are rare, and few reports have documented them[3]. However, it has been reported that once the lingual nerve has been injured, recovery of sensation, taste, and salivary secretion may be compromised[9,18]. Therefore, it is necessary to be aware that lingual nerve sensory disorders can occur accidentally during mandibular wisdom tooth extraction. The average total fascicular area of the sural nerve was $0.76\,mm^2$ according to a report by Kundalić *et al*[13]. In the present study, it was concluded that the average total fascicular area of the lingual nerve was $1.90\,mm^2$, which is greater than that of the sural nerve. However, when a nerve graft procedure results in damage to the lingual nerve, the sural nerve is the first choice of donor nerve for grafting[14]. Therefore, the present results suggest that, even though the total fascicular area of the donor nerve is a little smaller than that of the recipient nerve, nerve grafting should be successful.

The great auricular nerve is also known to be a good donor nerve because it is easily accessible in view of its convenient location beneath the platysma muscle, and it can be harvested during nerve graft procedures in the head and neck region without the need for additional surgery. Yang *et al.* noted that the total fascicular area of the great auricular nerve decreased in a proximal (point of emergence on the posterior border of the SCM) $(1.42\,mm^2)$ to a distal (prior to the point of bifurcation into the anterior and posterior branches) $(0.60\,mm^2)$ direction[23]. In the present study, it was concluded that the average total fascicular area of the lingual nerve was $1.90\,mm^2$. As repair of the lingual nerve is performed using nerve grafting, a graft from the proximal region of the great auricular nerve is better than one from the distal region.

The submandibular ganglion has been described in numerous anatomic textbooks as a separate entity suspended from the lingual nerve by its pre- and post-ganglionic nerve fibers. However, in the present study, ganglion cells were seen in 1 of the 4 specimens, where they mixed with nerve fibers in a fascicle. Smith and Harn also reported that the lingual nerve included ganglion-like clusters in the area of the third molar in 50% of cases[21]. Therefore, it can be inferred that these cell bodies have a parasympathetic function. The presence of cell bodies within the lingual nerve in the area of the third molar suggests that the distribution of the submandibular ganglion is more complicated than previously described.

The mandible can be subdivided into the alveolar and basilar processes based on the presence of reversal lines, which delineate the most inferior extent to which alveolar reduction is likely to progress[5]. Measurements of edentulous bone have indicated that the shape of the alveolar bone changes significantly in both the horizontal and vertical axes. However, the shape of the basal bone does not change significantly, unless it is subjected to harmful local effects, such as overloading due to ill-fitting dentures[3]. On the other hand, it was reported that the lingual nerve is located at the level of the alveolar crest or higher in 17.6% of cases[10], whereas Behnia *et al.* reported that it was observed in this position in about 10% of cases[1]. In the present study, a Japanese case is described in which the lingual nerve passed at the level of the alveolar crest or higher. However, little attention has been given to differences in the location of the lingual nerve between dentulous and edentulous bone. It is presumed that the appearance of the lingual nerve at the level of the alveolar crest or higher is related to tooth loss.

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