Anatomy of the Lingual Nerve: Application to Oral Surgery

ABSTRACT

The purpose of this research is to obtain morphological information about the traveling route, branching pattern, and distribution within the tongue of the lingual nerve, all of which are important for oral surgical procedures. Using 20 sides from 10 Japanese cadaveric heads, we followed the lingual nerve from its merging point with the chorda tympani to its peripheral terminal in the tongue. We focused on the collateral branches in the area before reaching the tongue and the communication between the lingual and hypoglossal nerves reaching the tongue. The collateral branches of the lingual nerve were distributed in the oral mucosa between the palatoglossal arch and the mandibular molar region. Two to eight collateral branches arose from the main trunk of the nerve, and the configuration of branching was classified into three types. More distally, the lingual nerve started to communicate with the hypoglossal nerve before passing the anterior border of the hyoglossus muscle. Nerve communications were also found in the main body and near the apex of the tongue. A thorough understanding of the collateral branches near the tongue, and the communication with the hypoglossal nerve inside the tongue, will help to prevent functional disorders from local anesthesia and oral surgical procedures associated with the lingual nerve.

Keywords: oral surgical procedures; lingual nerve; hypoglossal nerve; innervation; anatomy

INTRODUCTION

There are many variations in the traveling route and branching pattern of the lingual nerve, which is one of the sensory branches of the mandibular nerve. Because the lingual nerve travels along the inner surface of the mandible, the risk of nerve during dental and maxillofacial treatment is higher on the lingual side of the mandible (Pogrel et al., 1995; Behnia et al., 2000; Holzle and Wolff 2001). In particular, full attention is required if there is an impacted wisdom tooth near the mandibular canal or when a mandibular tooth with a large periapical lesion is removed (Chiapasco et al., 1993; Middlehurst et al., 1998; Dolnmaz et al., 2009; Shinohara et al., 2010). The inferior alveolar nerve block, which is performed in both routine tooth extraction and complex oral treatments, can block the inferior alveolar and lingual nerves simultaneously because of their proximity. Postanesthetic numbness often persists because of this topographical relationship (Cheung et al., 2010; Xu et al., 2013; Pippi et al., 2017). Thus, the lingual nerve can be routinely exposed to injury during anesthetic and oral surgical procedures.

It is also important to understand the distribution of nerves in the tongue for a glossectomy, which is usually performed to treat tongue cancer, to minimize postoperative functional disorders. There has been a great deal of clinical research in the field of oral surgery regarding the lingual nerve. However, a few reports have pursued its detailed course and its branching pattern anatomically using the naked eye (Abd-El-Malek., 1939; FitzGerand and Law., 1958; Zur et al., 2004), rather than clinical research. Therefore, the purpose of the present study is to obtain morphological information about the traveling route, branching pattern, and distribution of the lingual nerve within the tongue, all of which are important oral surgical procedures.

MATERIALS AND METHODS

Eighteen sides from nine Japanese cadaveric heads and two harvested and stored specimens perfused with 10% formalin and preserved in 30% ethanol were used in this study. The specimens were from seven males and three females. The age at death ranged from 62 to 86 years (mean age: 76.3 ± 6.02 years). Eighteen of the specimens were freshly prepared for this study. The remaining two were preserved specimens, which had been partly dissected in a previous study of the lingual muscle (Ogata et al. 2002). The cadavers were voluntarily donated to the Kagoshima University for education and research with documented forms of permission, according to the Japanese Law, 'Act on Body Donation for Medical and Dental Education'. The research was approved by the local Ethics Committee.

First, we carefully followed the lingual nerve, which ran in an anteroinferior direction between the lateral and the medial pterygoid muscles along the lateral surface of the medial pterygoid muscle. It continued diagonally across the superior pharyngeal constrictor and lateral surface of the styloglossus muscle until it reached the lateral surface of the tongue. During this course, it gave off collateral branches heading toward the fauces. The lingual neve communicates with the inferior alveolar, mylohyoid, auriculotemporal and masticatory muscle nerves in many cases; it has been reported that it communicates with the inferior alveolar nerve in 30% to 60% of individuals (Kim et al., 2004; Shinohara et al., 2010). We initially observed the communication of the inferior alveolar nerve with the lingual nerve in some specimens. However, in the causes used in this study, the inferior alveolar nerve was cut around the level of the mandibular foramen because the mandible had been removed during the student dissection course. Therefore, the communication between the lingual nerve and other branches of the mandibular nerve could not be counted precisely. Nevertheless, the communication between the lingual and mylohyoid nerves distal to the submandibular ganglion was observed in two specimens. For these reasons, we limited the observation of the collateral branches to the section where the lingual nerve and chorda tympani merge with the ganglionic branches and submandibular ganglion. In this section, we observed the branching morphology, that is, the position at which branches were given off from the main trunk of the lingual nerve, the number of branches, the branching configuration, and the area of distribution.

Second, we exposed the lingual and hypoglossal nerves running over the lateral surface of the hyoglossus muscle and dissected the nerves and their branches from the inferolateral surface of the tongue up to the apex of the tongue. The specimen was immersed in water and examined using a stereoscopic microscope. The specimens were then photographed and line drawings were made. The process of tongue dissection and recording basically followed Ogata et al. (2002).

RESULTS

Collateral branches of the Lingual Nerve

Collateral branches were found in all specimens in the section from the point where the lingual nerve merged with the chorda tympani to the ganglionic branches to the submandibular ganglion (Fig. 1). These small branches were distributed in the oral mucosa between the palatoglossal arch and the region of the mandibular molar. The number of branches was two to eight (Fig. 2A, B, C). The breakdown of the number of collateral branches was as follows: two were 2/20 (10%), three were 3/20 (15%), four were 7/20 (35%), five were 3/20 (15%), six were 3/20 (15%), seven were 1/20 (5%), and eight were 1/20 (5%) specimens.

For all of the specimens, the lowermost collateral branch originated from the main trunk of the lingual nerve at a short distance from the upper branches. After passing through the cheek wall in an upward direction on the mylohyoid muscle, the lingual nerve headed toward the mucosa near the retromolar pad.

The configuration of the collateral branches was classified into three types (Fig. 3):

Type I: branches given off from the main trunk at almost equal intervals

Type II: branches given off from the main trunk with mutual communication

Type III: branches given off from the subdivided trunk

The frequency of each type was 11/20 (55%) for type I, 6/20 (30%) for type II, and 3/20 (15%) for type III.

Communication between the Lingual Nerve and Hypoglossal Nerve

The communication between the lingual nerve and hypoglossal nerve began to make loops over the hyoglossus muscle before turning in at the anterior border of the muscle and entering into the deep part of the tongue. Extralingual loops were observed in several locations and presented in the shape of a nerve plexus (Fig. 4.).

More distally, the intralingual communications were found around the genioglossus muscle and near the apex of the tongue. The communications in the middle part of the anterior two-thirds of the tongue constituted a plexiform appearance formed by the rather thick branches derived from both nerves. In contrast, the anterior communication was a thin loop between the ipsilateral branches located 10 mm away from the apex of the tongue and within

10 mm of the lingual septum. Such communications between the lingual and hypoglossal nerves were found at three sites. Although the complexity and thickness of the communication between the nerves differed among specimens, the form was essentially common throughout. In the apex of the tongue, there was anastomosis between the contralateral terminal branches of the lingual nerve; however, these were not true communications. In the middle part of the anterior two-thirds of the tongue, no terminal branch of the lingual nerve crossed the lingual septum to reach the opposite side.

DISCUSSION

Collateral Branches of the Lingual Nerve

For the collateral branches of the lingual nerve in proximity to the tongue, the anatomical term “branches to isthmus of fauces” was used in the Terminologia Anatomica (Federative Committee on Anatomical Terminology, 1998); however, the area of their distribution was not defined and has been less described in anatomy textbooks. Staubesand (1990) and Standring (2004) did not include these branches, and both Spalteholz and Spanner (1967), and Pernkopf and Ferner (1979) drew them as small branches in the elaborated figures.

Kamijyo (1965) and Sekine (1974) used the term "rami isthmi faucium" listed in the Paris Nomina Anatomica, which was approved in 1955, whereas Watanabe et al. (1995) called them the "buccal mucosa branch" of the lingual nerve. Kamijyo (1965) and Watanabe et al. (1995) counted two to three small branches, whereas Sekine (1974) counted one to three. In the present study, the number of collateral branches ranged from two to eight.

Of these collateral branches, the lowermost branch ran toward the mucosa in the retromolar pad. Taking into consideration the terminal distribution and clinical significance of the nerve, this branch should be distinguished from the branches extending to the isthmus of fauces. Kim et al. (2004) reported the branches to the retromolar pad at a frequency of 26/32 and called them "collateral nerve twigs" of the lingual nerve. This is consistent with our observations. On the other hand, Iwanaga et al. (2018) reported that a small branch of the lingual nerve supplied the minor salivary gland in the retromolar trigone, and suggested that the gland should be named the "retromolar gland." However, we could not ascertain whether it contained secretomotor fibers.

In minor operations on the mandibular teeth or periodontal tissues, an inferior alveolar nerve block is routinely performed. In many cases, the lingual nerve is simultaneously anesthetized (Pogrel et al. 2003). Therefore, appreciation of these branches and their distribution areas has major significance for achieving favorable outcomes in oral surgical procedures and minimizing postanesthetic complications associated with the lingual nerve.

Communication between the Lingual Nerve and Hypoglossal Nerve

The communication between the lingual nerve and the hypoglossal nerve was found at three sites of the tongue in all specimens. The communication started on the external surface of the hyoglossus muscle. When the dissected nerves were development on a two-dimensional plane, the plexiform shape became easily identifiable (Fig. 4). There were multiple thicker connections in the middle body of the tongue, but such connections were poorer and thinner near the tongue of apex. The prelingual and intralingual branchings of the lingual nerve and its communication with the hypoglossal nerve are represented by a schematic diagram in Fig. 5.

Most anatomy textbooks have only described this communication on the external surface or near the anterior border of the hyoglossus muscle (Staubesand., 1990; Standring., 2004). FitzGerald and Law (1958) observed the lateral and medial lingual-hypoglossal connections and assumed that the lateral connection corresponded to the extralingual communication. The medial connection can be divided into proximal and distal parts, which correspond to the communication in the middle body and near the apex of the tongue, respectively.

During the past two decades, Sihler's whole mount nerve-staining technique has been actively used to trace the course of the nerves and their branching patterns within the tongue. Zur et al. (2004) described two main branches of the lingual nerve in the body of tongue and found that both lateral and medial branches had anastomotic connections with the hypoglossal nerve. Mu and Sanders (2010) described three branches of the lingual nerve inside the tongue: an anterior branch to the tongue apex, a middle branch to the dorsal mucosa, and posterior branch supplying innervation to the inferior longitudinal and superior longitudinal muscles. These branches communicated with the lateral division of the hypoglossal nerve. Together with the finding of the last branch and a study by Saigusa et al. (2006), Mu and

Sanders suggested that the lingual nerve could contain motor axons to the inferior longitudinal and superior longitudinal muscles. Touré et al. (2005) examined the intralingual course of the nerves and demonstrated the anastomoses between the lingual, hypoglossal, and glossopharyngeal nerves. However, we could not verify the glossopharyngeal-lingual and glossopharyngeal-hypoglossal communications. Iwanaga et al. (2017) found communicating braches between the lingual and hypoglossal nerves in the anterior, middle, and posterior parts of the anterior two-thirds of the tongue. These works, which used Sihler's staining, demonstrated the entire intralingual course of the nerves and their branches. However, before the lingual and hypoglossal nerves entered the muscular mass of the tongue, the relationship between the nerves and muscles could not be determined for the transparentized specimens preserved in glycerin. In contrast, the perilingual and intralingual course of the lingual nerve, were well traced continuously, and the relationship to the extrinsic muscles of the tongue was determined in this study.

Glossectomy is performed not only for malignant tumor of tongue but also for macroglossia.

A small defect in partial glossectomy can usually be closed primarily. In setting any incision line for removal of lingual tissues (Touré et al. 2005; Balaji 2013), knowledge of the anatomical arrangement of the intralingual nerve can help the surgeon to pursue a more effective and safer procedure. As mentioned above, there is a possibility that the communicating branched convey motor fibers to the lingual muscles (Saigusa et al. 2006; Mu and Sanders 2010) along with proprioceptive fibers. For restoring the mobility and sensitivity of the tongue, attention should be paid to the communicating branches in addition to the main trunks of the hypoglossal nerve and lingual nerves.

On the other hand, a larger defect in hemi-, subtotal, or total glossectomy requires some form of tongue reconstruction. Loss of tongue bulk and scar contracture cause a decrease in lingual contact with the palate, teeth, lip, and cheek, and can result in impaired food bolus formation, dysphagia, speech disorder, and poor esthetics. Although various types of free flap have been designed and clinically applied, recovery of bulk and mobility of the neotongue are more likely to be emphasize than sensitivity, especially during the early phase of reconstruction. However, Bass et al. (2005) reported that sensory recovery after hemi- or total glossectomy could have a beneficial effect on overall tongue function. In tongue reconstruction, different recipient nerves and neurorrhaphy technique can be used for flap reinnervation. Multiple studies have found that using the lingual nerve as the recipient nerve led to better sensory recovery of the flap than the hypoglossal, posterior auricular, or cervical nerves (Santamaria et al. 1999; Boyd et al. 2013; Elfring et al. 2014; Namin and Varvares 2016). Therefore, the primary choice of recipient nerve on the basis of sensory outcome is the lingual nerve, although it depends absolutely on the diverse situations of lesion and donor sites.

Taking into consideration postoperative oral functions and esthetic satisfaction, the amount of resection should be kept to the minimum. A thorough understanding of the distribution of nerves in the tongue is very important for preventing disorders related to different functions such as swallowing, articulation, and sense of taste after oral surgical procedures, in order to remove tumors completely while preserving function.

ACKNOWLEDGEMENT

This work was supported by JSPS KAKENHI (Grant-in-Aid for Scientific Research (C) No.

JP17K12405). The authors would like to acknowledge their gratitude to the individuals of the study and their families who donated the bodies to allow this investigation to be performed. The authors have no conflicts of interest to declare.

REFERENCES

Abd-El-Malek S. 1939. Observations on the morphology of the human tongue. J Anat 73:201-210.

Pogrel MA, Schmidt BL, Sambajon V, Jordan RC. 2003. Lingual nerve damage due to inferior alveolar nerve blocks: A possible explanation. J Am Dent Assoc 134: 195-199.

Bass M, Duraku LS, Corten EML, Mureau MAM. 2015. A systematic review on the sensory innervation of free flaps for tongue reconstruction: Does improve sensibility imply functional benefit? J Plast Reconst Aesth Surg 68: 1025-1035.

Baiaji SM. 2013.Reduction glossectomy for karge tongues. Ann Maxilofac Surg 3: 167-172.

Behnia H, Kheradver A, Shahrokhi M. 2000. An anatomic study of the lingual nerve in the third molar region. J Oral Maxillofac Surg 58:649-651.

Boyd JB, Caton AM, Muholland RS, Granzow JW. 2013. The sensate fibular osteoneurocutaneous flap in oromandibular reconstruction: clinical outcomes in 31 cases. J Plast Reconstr Aesth Surg 66: 1695-1701.

Cheung LK, Leung YY, Chow LK, Wong MCM, Chan EKK, Fok YH. 2010. Incidence of neurosensory deficits and recovery after lower third molar surgery: a prospective clinical study of 4338 cases. Int J Oral Maxillofac Surg 39:320-326.

Chiapasco M, De Cicco L, Marrone G. 1993. Side effects and complications associated with third molar surgery. Oral Surg Oral Med Oral Pathol 76:412-420.

Dolnmaz D, Yildirim G, Isik K, Kucuk K, Ozturk A. 2009. A preferable technique for protecting the inferior alveolar nerve: coronectomy. J Oral Maxillofac Surg 67:1234-1238.

Elfring T, Boliek CA, Winget M, Paulsen C, Seikaly H, Rieger JM.. 2014. The relationship between lingual and hypoglossal nerve function and quality of life in head and neck cancer. J Oral Rehabil 41: 135-140.

Federative Committee on Anatomical Terminology. 1998. Terminologia anatomica. Stuuugart:

Thieme.

FitzGerand MJ, Law ME. 1958. The peripheral connexions between the lingual and hypoglossal nerves. J Anat 92:178-188.

Holzle FW, Wolff KD. 2001. Anatomical position of the lingual nerve in the mandibular third molar region with special consideration of an atrophied mandibular crest: an anatomical study. Int J Oral Maxillofac Surg 30:333-338.

Iwanaga J, Watanabe K, Saga T, Tabira Y, Nakamura M, Fisahn C, Tubbs RS, Kusuwaka J, Yamaki K. 2017. Communication branches between lingual and hypoglossal nerve: observation using Sihlers's staining technique. Surg Radiol Anat 39: 741-745.

Iwanaga J, Nakamura K, Alonso F, Kirkpatrick C, Oskouian RJ, Watanabe K, Tubbs RS. 2018. Anatomical study of the so-called "retromolar gland" distinguishing normal anatomy from oral cavity pathology. Clin Anat 31: 462-465.

Kamijyo Y. 1965. Oral Anatomy 4. Tokyo: Anatomu-sya Publication. p898-901.

Kim SY, Hu KS, Chung IH, Lee EW, Kim HJ. 2004. Topographic anatomy of the lingual nerve and variations in communication pattern of the mandibular nerve branches. Surg Radiol

Anat 26:128-135.

Middlehurst RJ, Barker GR, Rood JP. 1998. Postoperative morbidity with mandibular third molar surgery: A comparison of two techniques. J Oral Maxillofac Surg 46:474-475.

Mu L, Sanders I. 2010. Human tongue neuroanatomy: nerve supply and motor endplates. Clin Anat 23: 777-791.

Namin AW, Varares MA. 2016. Functional outcomes of sensate versus insensate free flap reconstruction in oral and oropharyngeal reconstruction: A systematic review. Head Neck 38: 1717-1721.

Ogata S, Mine K, Tamatsu Y, Shimada K. 2002. Morphological study of the human chondroglossus muscle in Japanese. Ann Anat 184: 493-499.

Pernkopf E, Ferner H (eds). 1979. Pernkopf anatomy: atlas of topographic and applied human anatomy: volume 1; head and neck. Munich: Urban & Schwarzenberg.

Pippi R, Spota A, Santoro M. 2017. Prevention of lingual nerve injury in third molar surgery: literature review. J Oral Maxillofac Surg 75:890-900.

Pogrel MA, Renaut A, Schmidt B, Ammar A. 1995. The relationship of the lingual nerve to the mandibular third molar region: An anatomic study. J Oral Maxillofac Surg 53:1178-1181.

Saigusa H, Tamura K, Yamashita K, Saigusa M, Niimi S. 2006. Nerve fiber analysis for the lingual nerve of the human adult subjects. Surg Radiol Anat 28: 59-65.

Santamaria E, Wei FC, Chen IH, Chung DC. 1999. Sensation recovery on innervates radial forearm flap for hemiglossectomy reconstruction by using different recipient nerves. Palst Reconstr Surg 103: 450-457.

Sekine K. 1974. Studies on innervation of so-called Plica intermaxillomandibularis, a predilection site causing shock. Jpn J Oral Maxillofac Surg 20:324-341.

Shinohara H, Mataga I, Kageyama I. 2010. Discussion of clinical anatomy of the lingual nerves. Okajimas Folia Anat Jpn 87:97-102.

Spalteholz W, Spanner R (eds). 1967. Atlas of human anatomy. London: Butterworth & Co Publishers Ltd.

Standring S (eds). 2004. Gray's anatomy: the anatomical basis of medicine and surgery. 40th ed. London: Elsevier.

Staubesand J. Head. 1990. Sobotta atlas of human anatomy. 15th ed. Volume 1. Baltimore:

Urban & Schwarzenberg, Inc.

Touré G, Bicchieray L, Selva J, Vacher C. 2005. The intra-lingual course of the nerves of the toungue. Surg Radiol Anat 27: 297-302.

Watanabe K, Dohi F, Tomita H. 1995. Topographical anatomy of the chorda tympani nerve. Practica oto-rhino-laryngologica Suppl 78:53-62.

Xu GZ, Yang C, Fan XD, Yu CQ, Cai XY, Wang Y, He DM. 2013. Anatomic relationship between impacted third mandibular molar and mandibular canal as the risk factor of inferior alveolar nerve injury. Br J Oral Maxillofac Surg 51:215-9.

Zur KB, Mu L, Sanders I. 2004. Distribution pattern of the human lingual nerve. Clin Anat 17:88-92.

Legends

Fig. 1. Lateral view of the left side of the cranium after removing mandibular bone. The collateral branches arise from the main trunk of the lingual nerve at equal intervals (Type I). CT, chorda tympani; IAN, inferior alveolar nerve; LN, lingual nerve; MN, mylohyoid nerve; SG, submandibular ganglion. Scale bar=10 mm.

Fig. 2A. Collateral branches of the left side of the cranium classified as Type I. The branches arise from the main trunk at almost equal intervals. The uppermost branch bifurcates into a hoe-like shape. CT, chorda tympani; IAN, inferior alveolar nerve; LN, lingual nerve; MN, mylohyoid nerve; SG,submandibular ganglion. Scale bar=10 mm.

Fig. 2B. Collateral branches of the left side of the cranium classified as Type II. The branches arise from the main trunk with mutual communication. LN, lingual nerve. Scale bar=10 mm.

Fig. 2C. Collateral branches of the left side of the cranium classified as Type III. The branches arise from the subdivided trunk. CT, chorda tympani; IAN, inferior alveolar nerve; LN, lingual nerve; MN, mylohyoid nerve; SG, submandibular ganglion. Scale bar=10 mm.

Fig. 3. Schematic diagram of the three types of branching configurations of the collateral branches. Refer to Fig. 2 for more details. LN, lingual nerve.

Fig. 4. Photograph of the lingual and hypoglossal nerves developed on the 2D plane. Communications (arrows) between the lingual nerve and hypoglossal nerve are present at three sites: outside (I), in the middle body (II), and near the apex of the tongue (III). The communicating branch near the tongue apex (*) is shown. HN, hypoglossal nerve; LN, lingual nerve; GhM, geniohyoid muscle; GM, genioglossus muscle; HM, hyoglossus muscle; SM, styloglossus muscle; TM, thyrohyoid muscle. Scale bar=10 mm.

Fig. 5. Schematic diagram showing the branching and communication of the lingual neve. The collateral branches were determined as Type I. The lowermost collateral branch extended

into the retromolar pad. There were communications between the lingual and hypoglossal nerves outside (I), in the main body (II), and near the apex of the tongue (III). HN, hypoglossal nerve; IAN, inferior alveolar nerve; LN, lingual nerve; MN, mylohyoid nerve; CT, chorda tympani; GhM, geniohyoid muscle; GM, genioglossus muscle; HM, hyoglossus muscle; SM, styloglossus muscle; TM, thyrohyoid muscle; SG, submandibular ganglion.

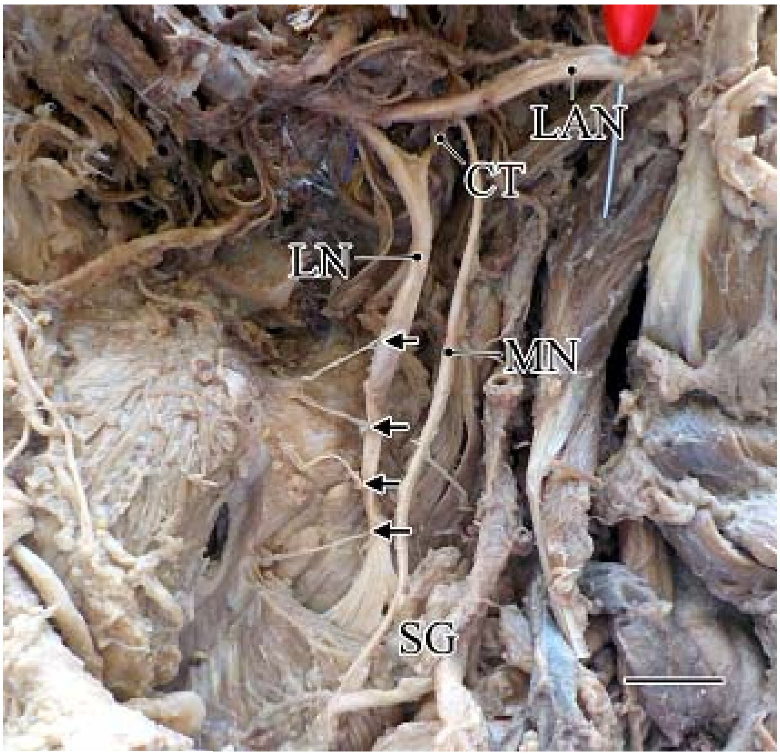
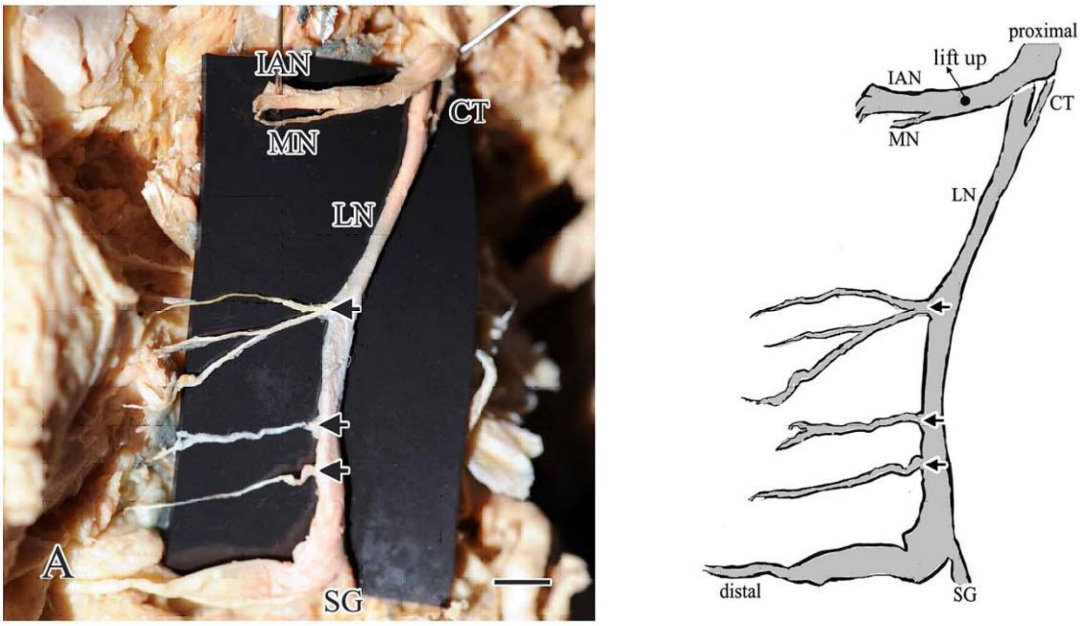

LAN
CT
LN
MN
SG

Fig.1


IAN
CT
MN
LN
A
SG
proximal
lift up
IAN
CT
MN
LN
distal
SG

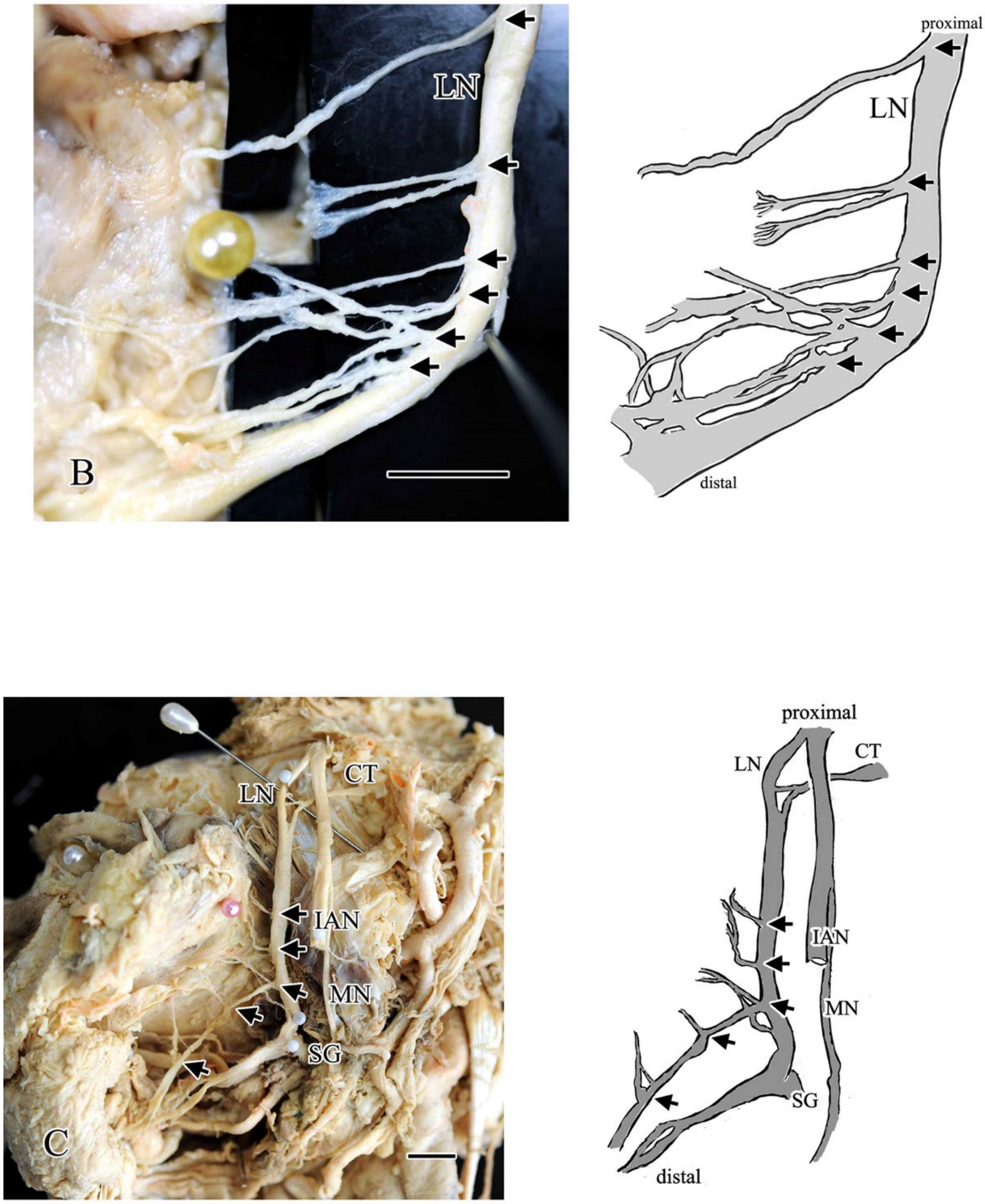

LN
B
proximal
LN
distal
CT
LN
IAN
MN
SG
C
proximal
LN
CT
IAN
MN
SG
distal

Fig.2

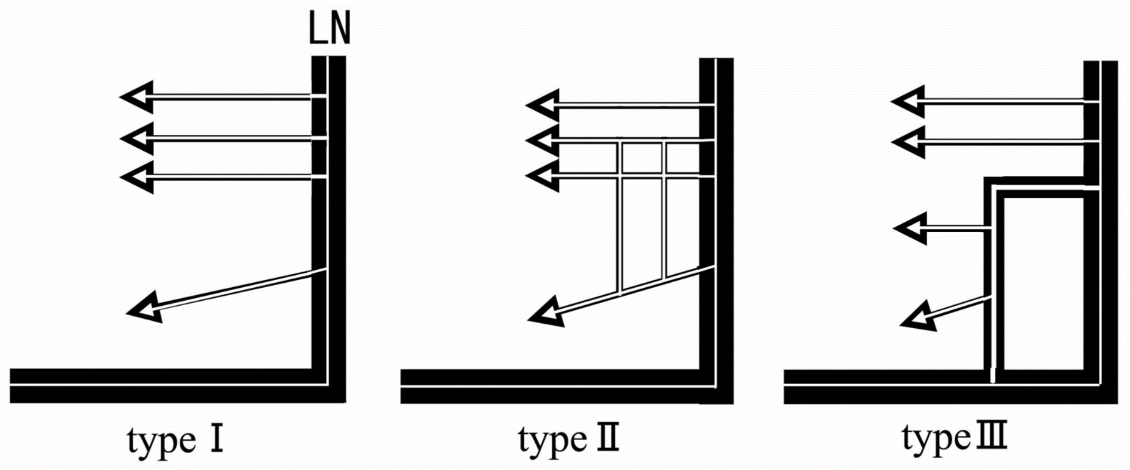


Fig.3

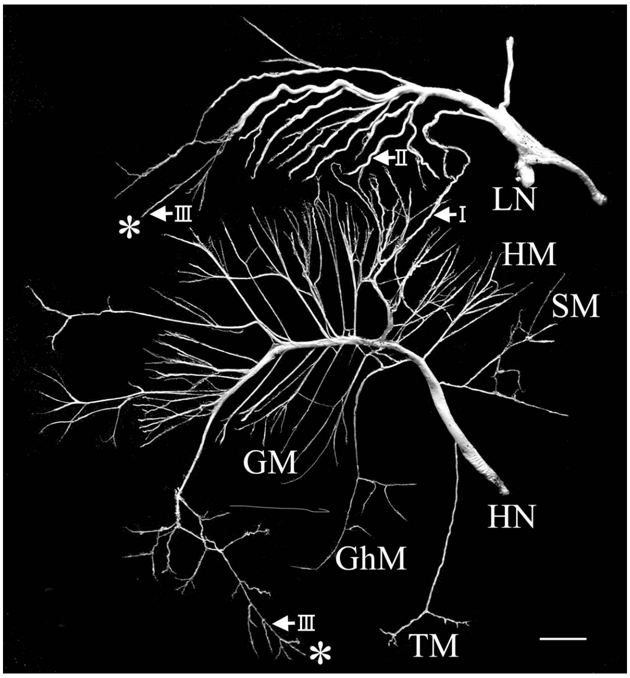


Fig.4

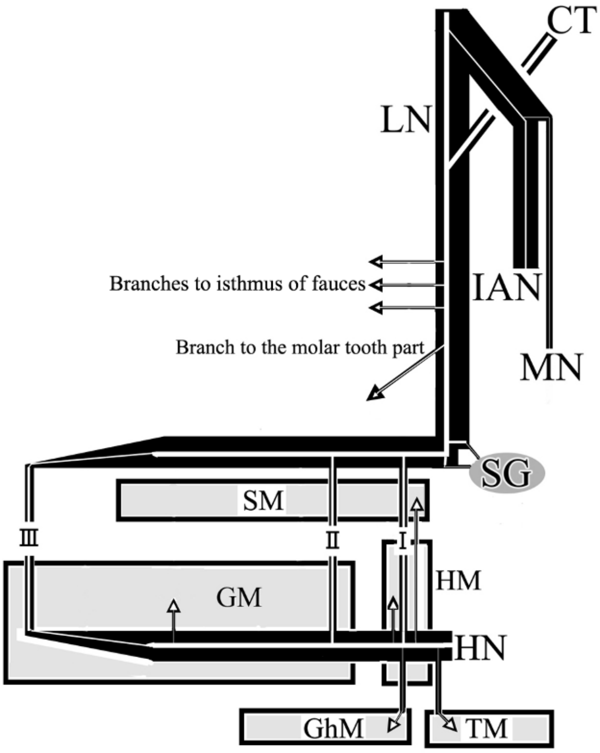

CT
LN
Branches to isthmus of fauces
IAN
Branch to the molar tooth part
MN
SG
SM
Ⅲ
Ⅱ
Ⅰ
HM
GM
HN
GhM
TM

Fig.5