The courses and distributions of the lingual nerve in the ventral tongue region; Anatomical consideration for frenectomy

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The courses and distributions of the lingual nerve in the ventral tongue region; Anatomical consideration for frenectomy

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모든 분들께 진심으로 감사드립니다.

2008년 12월

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Abstract

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The aim of this study was to elucidate the intra- and sub-lingual course of the lingual nerve (LN) at the ventral tongue region and to serve as the clinical guidance for safe surgical procedures such as frenectomy. We evaluated sixteen specimens by means of gross observation after detailed dissections, and six specimens visualized by Sihler's staining. All specimens were harvested from the embalmed Korean cadavers. We classified the proceeding patterns of the LN into 5 types and confirmed the distribution of the LN on the tongue tip. The classification of the LN was made with reference to the line in which the styloglossus (SG) and genioglossus muscle (GG) interlaced. Based on the course of LN and the existence of the tiny twig directly innervating to the sublingual mucosa (TM), the LN was classified into straight, curved and vertical pattern with or without the TM. Without the TM, Shown were the straight pattern in 9.4%, curved pattern in 46.9% and vertical pattern in 18.8%. Not having the TM, the straight pattern and curved pattern was present in 6.3% and in 18.8%, repectively. The results from the Sihler's staining analysis demonstrated that the region of the tongue tip was innervated by the LN. The

present study proposed that surgical manipulations at the ventral tongue region may damage the LN and result in numbness the tongue tip and provided useful anatomical reference for the various surgical procedures at the ventral tongue region.

Key words : lingual nerve, tongue tip, lingual frenulum, frenectomy, frenuloplasty, Sihler's staining

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Ⅰ. INTRODUCTION

The lingual nerve (LN) is originated from the posterior trunk of the mandibulare nerve and carries general sensation from the anterior two-thirds of the tongue, the lingual mucosa on the floor of the oral cavity and lingual gingiva associated with the lower teeth (Heasman and Beynon, 1986). After passing through the infratemporal fossa and proceeding between the mandibular ramus and the medial pterygoid, the LN enters into the tongue on the lateral surface of the hyoglossus muscle (HG) (Kim et al., 2004). Nerve twigs of the LN reach the tip of the tongue supplying afferent nerve fibers to the ventral region of the tongue (Standring, 2005; Saigusa et al., 2006).

Injury to the lingual nerve often occurs during extraction of the third

molar, local anesthesia, orthognathic surgery, preprosthetic surgery, tumor excision, or face mask ventilation (McGeachie, 2002; Graff-Radford and Evans, 2003; Kim et al., 2004; Brimacombe et al., 2005; Smith and Lung, 2006; Tolstunov, 2007). Hence, the anatomical studies of the LN mainly have been focused on courses at the regions of the mouth floor and the retromolar trigone which are susceptible to injury during these manipulations (Lauretano et al., 1997; McGeachie, 2002; Graff-Radford and Evans, 2003; Kim et al., 2004). However, it is necessary for performing safety surgical procedures such as frenectomy and partial glossectomy for the ankyloglossia (tongue-tie), macroglossia or tongue cancer to recognize anatomy of the sub- and intra-lingual course and position of the LN at the ventral region of the tongue comprising the lingual frenulum. (Tantawi, 1969; Allison et al., 1971; Winstock and Warnakulasuriya, 1986; Herren et al., 1989; Wright, 1995; Garcia et al. 2002; Lalakea and Messner, 2003; Fiorotti et al., 2004; Gallegos-Hernandez et al., 2004; Queiroz, 2004; Hall and Renfrew, 2005; Heller and Gabbay, 2005; Ostapiuk, 2006; Wallace and Clarke, 2006; Segal et al., 2007; Wang et al., 2008). There are some descriptions of the lingual innervations using by classical methods such as gross anatomical dissection in cadaveric studies, neural tracing techniques and electrophysiology (El-Malek, 1938; Lawn, 1966; Yamamoto, 1975; Loew, 1980). However, few detailed neuroanatomical depiction has not been demonstrated for the LN at the ventral tongue region, regarding these surgical interventions. Furthermore, it is difficult to dissect the LN in their intra-lingual distributions without marked modification of the course of the nerve branches (Zur et al., 2004; Toure et al., 2005). Whereas Sihler's nerve staining makes whole specimens translucent while counterstaining nerves, and hence a detailed view of the nerve branches and their ends can be examined without the modifications of the courses of the nerve branches (Sanders et al., 1993; Mu and Sanders, 1996; Mu and Sanders, 1998; Mu and

Sanders, 1999).

In this study, investigations were performed elucidating sub- and intra-lingual topography of the LN at the ventral tongue region to serve as a reference of various surgical interventions by means of the gross anatomical observation and Sihler's nerve staining.

Ⅱ. MATERIALS & METHODS

1. Materials

Twenty-two specimens of tongue were used in present study (12 males, 10 females; average 69.0 age years) and they were harvested from the embalmed Korean cadavers. Gross anatomical dissections were made on the LN in 16 specimens. Nerve staining was performed on six specimens in accordance with modified Sihler's staining method.

2. Methods

A. Proceeding patterns of the lingual nerve

The sublingual mucosa was delicately stripped off in the ventral tongue region and connective tissue was removed by a detailed dissection for identifying the topography of the LN, HG, SG and SS. The reference line (S-G line) was established where the SG and the SS interlaced and the reference point (T point) was set on the point where the S-G line of the each side met. The classification was made according to the course of the most medial branch of the LN (mLN) at the ventral tongue region and the presence of the nerve twigs of the LN directly innervating to the lingual mucosa (TM). The right and left sides of the specimen were separately regarded as an independent observation object. On completion of the dissection, the topography of the mLN was classified into five types as follows (Fig. 1).

Type Ⅰa: mLN proceeding straight along the S-L line, not having the TM.

Type Ⅰb: mLN proceeding straight along the S-L line, baring the TM.

Type Ⅱa: mLN proceeding curvedly with a distance from the S-L line, not having the TM.

Type Ⅱb: mLN proceeding with a curved keeping a distance from the S-L

line, baring the TM.

Type Ⅲ: mLN proceeding anteriorly on the SG, and ascending vertically near the midline, not having the TM.

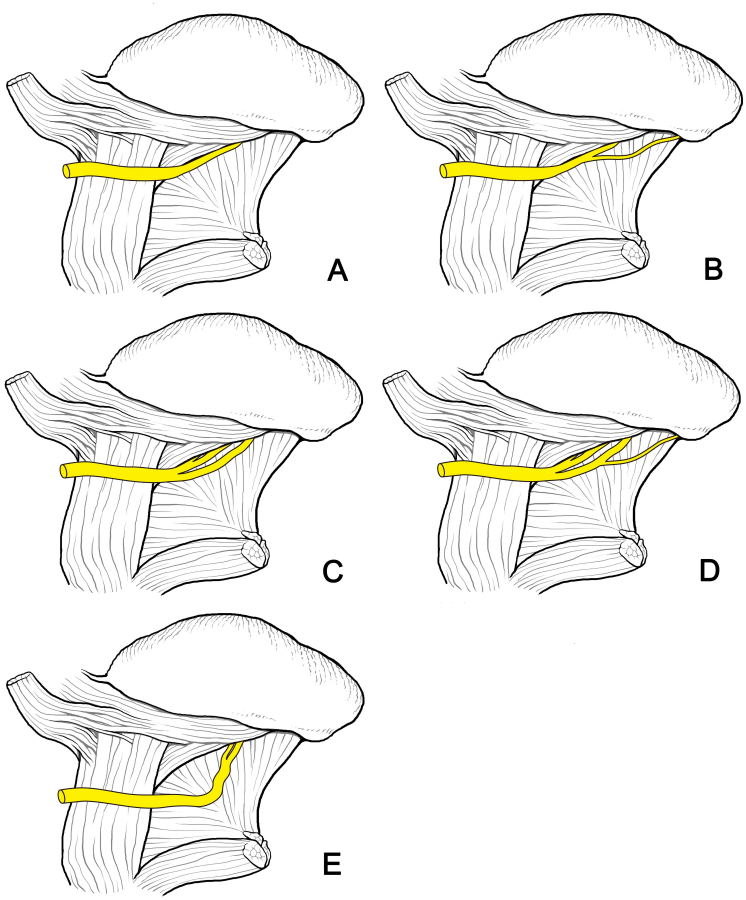


Fig. 1. Classification of the course of the lingual nerve (LN) into five patterns. A, Type Ⅰa; B, Type Ⅰb; C, Type Ⅱa; D, Type Ⅱb; E, Type Ⅲ.

B. Preparation of Sihler's staining for elucidating the innervations at the tongue tip

Modified Sihler's nerve staining technique was performed for the

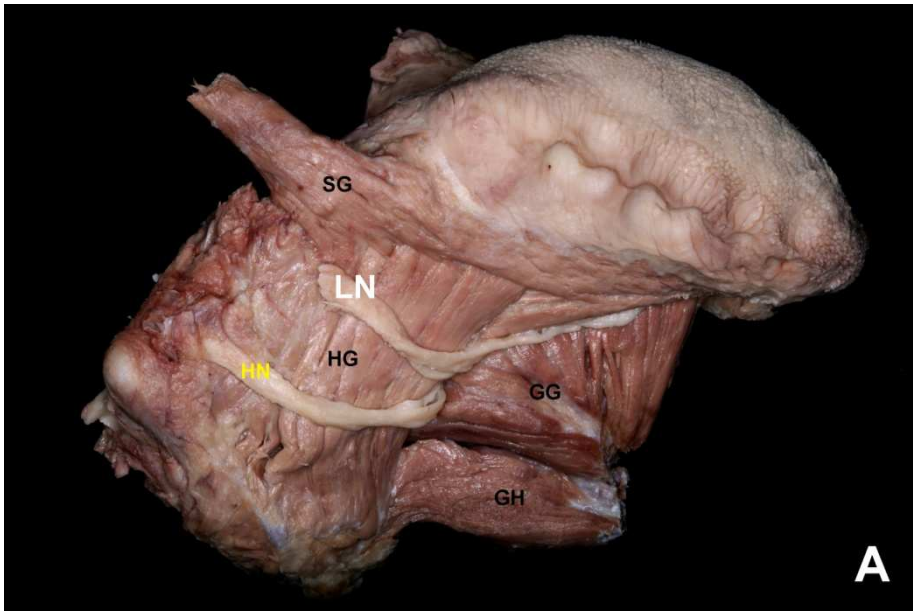
observation of the nerve distribution at the ventral tongue region (Fig. 4). 10% unneutralized formalin was injected through blood vessels for fixation of the muscles (fixation). Fixed muscles were washed using irrigation water, and deposited in 3% aqueous potassium hydroxide solution with addition of 0.2 ml of 3% hydrogen peroxide solution for 4 weeks (maceration and depigmentation). One part glacial acetic acid, one part glycerin, and six parts of 1% aqueous chloral hydrate constituted the Sihler solution I. After maceration, muscles were transferred into Sihler solution I (decalcification). Sihler's solution II was composed of one part Ehrlich hematoxylin, one part glycerin, and six parts 1% aqueous chloral hydrate. Decalcified specimens were stained by immersion and placed in Sihler's solution II in for three or four weeks (Staining). After staining, muscles were treated with Sihler's solution I to de-stain muscular fibers for one or two hours (Destaining). The destained specimens were washed in running tap water for 90 minutes and deposited in 0.05% lithium carbonate solution for 1 hour (Neutralization). After the neutralization, the specimens was treated with daily increasing concentrati ons of glycerin (40%, 60%, 80%, and 100%) (Clearing).

Ⅲ. RESULTS

1. Lingual nerve courses at the ventral tongue

A. Overall courses

The LN courses of 32 sides at the ventral tongue region were detected in the 16 specimens. Most of the LN branches traveled along the S-G line. The mLN of right and left side approached each other near the T point (tongue tip) and then entered between the SG and SS. However, there was no case of the mLN reaching or extending beyond the midline prior to inserting the muscle. The mLN were categorized into the 5 types according to the courses with reference to the S-G line and the presence of the TM (Fig. 2) (Table 1). 15.6% (5 cases) of the total was observed as the straight type while 9.4% (3 cases) lacked the TM (Type Ia) (Fig. 2a), and 6.3% (2 cases) had a TM (Type Ib) (Fig. 2b). The curved type (65.6%, 15 cases) was the most common and divided into Type IIa (without the TM) (Fig. 2c) and Type IIb (with the TM) (Fig. 2d), which constituted 46.9% (15 cases) and 18.8% (6 cases) of the overall findings respectively. The vertical type without the TM (Type III) (Fig. 2e) was found in 18.8% (6 cases). There was no case of the vertical type with the TM. In 25.0% of the cases, there was the TM, while disregarding the courses of the mLN. The TM was proceeding medially and reached to the mucosa of middle of the tongue tip (Fig. 3).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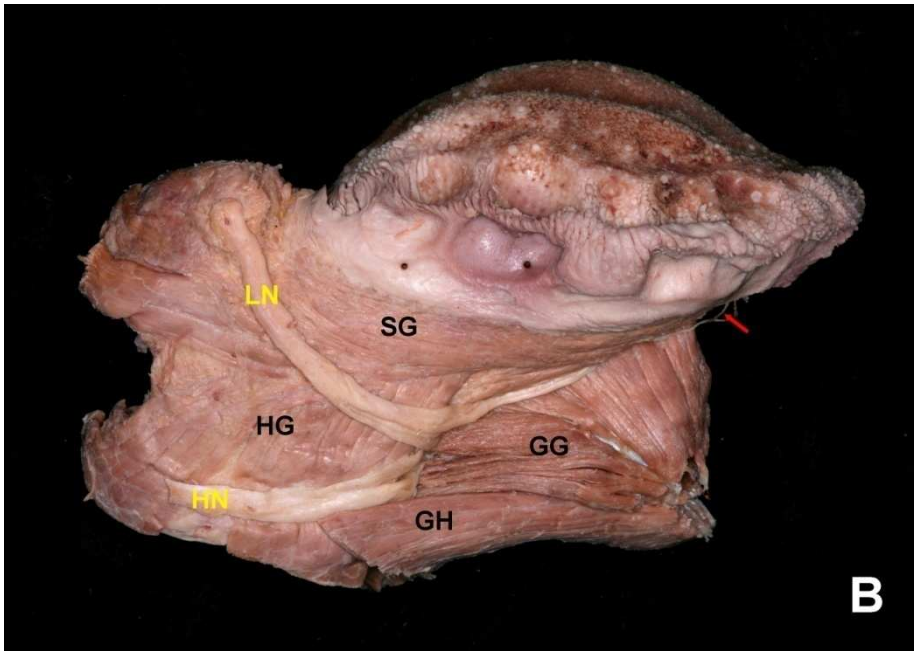
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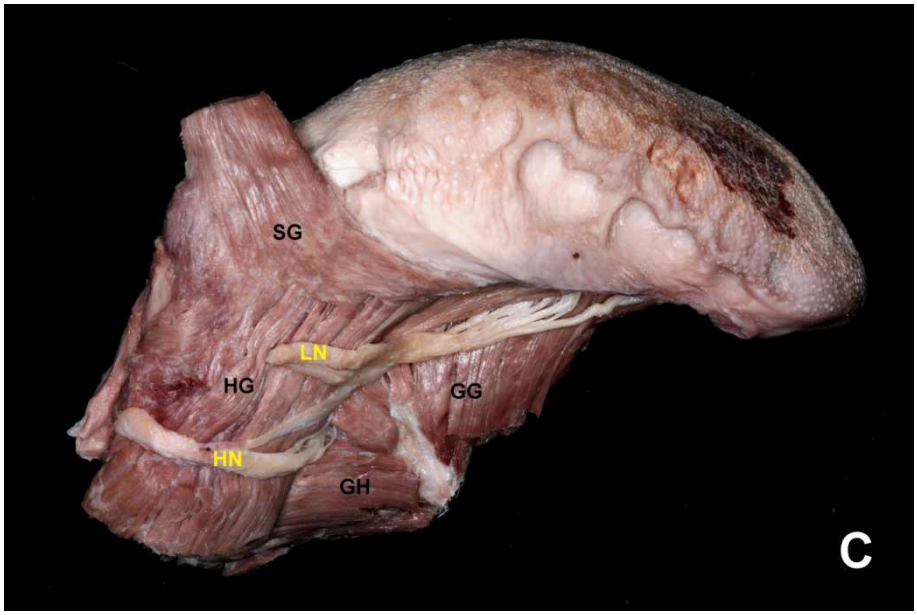
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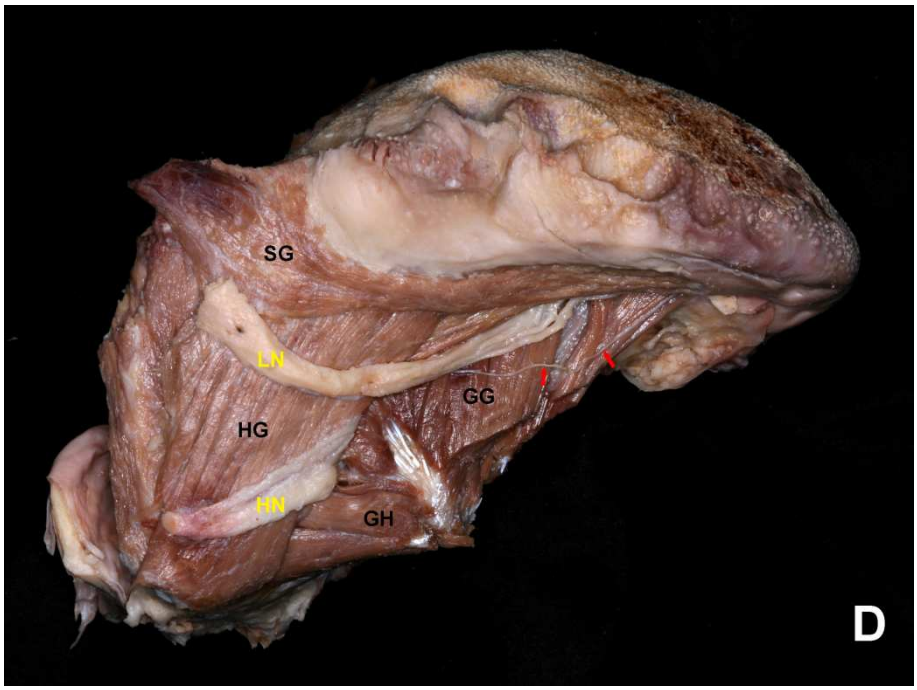
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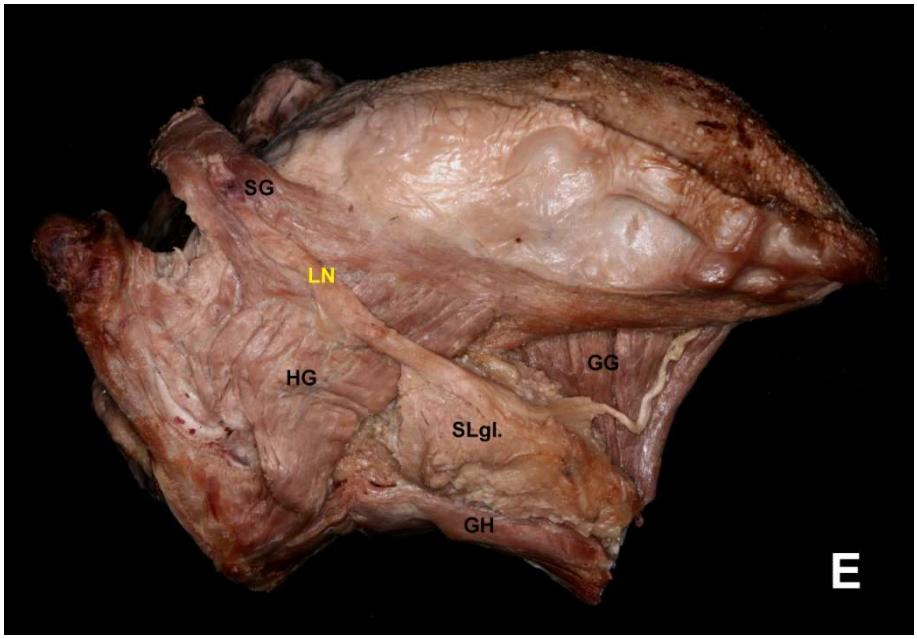

Fig. 2. Five patterns of the proceeding course of the lingual nerve (LN). A, Type Ia, straight type without the mucosal twigs (TM); B, Type Ib, straight with the TM; C, Type IIa, curved type without the TM; D, Type IIb, curved type with the TM; E, Type III, vertical type without the TM. Arrow points the TM. All specimen presented is right side. SG, styloglossus; GG, genioglossus; HG, hyoglossus; GH, geniohyoid; SLgl., Sublingual gland; LN, lingual nerve; TM, twigs directly innervting to the ventral mucosa of the tongue.

Table 1. Frequency of each type of lingual nerve proceeding courses

Courses of the lingual nerve at the ventral tongue region	Courses of the lingual nerve at the ventral tongue region		
	Straight (15.7%)	Curved (65.6%)	Vertical (18.8%)
Absence (75.0%)	Type Ⅰa	Type Ⅱb	Type Ⅲa
	9.4%	46.9%	18.9%
Presence (25.0%)	Type Ⅰb	Type Ⅱb	
	6.3%	18.8%	

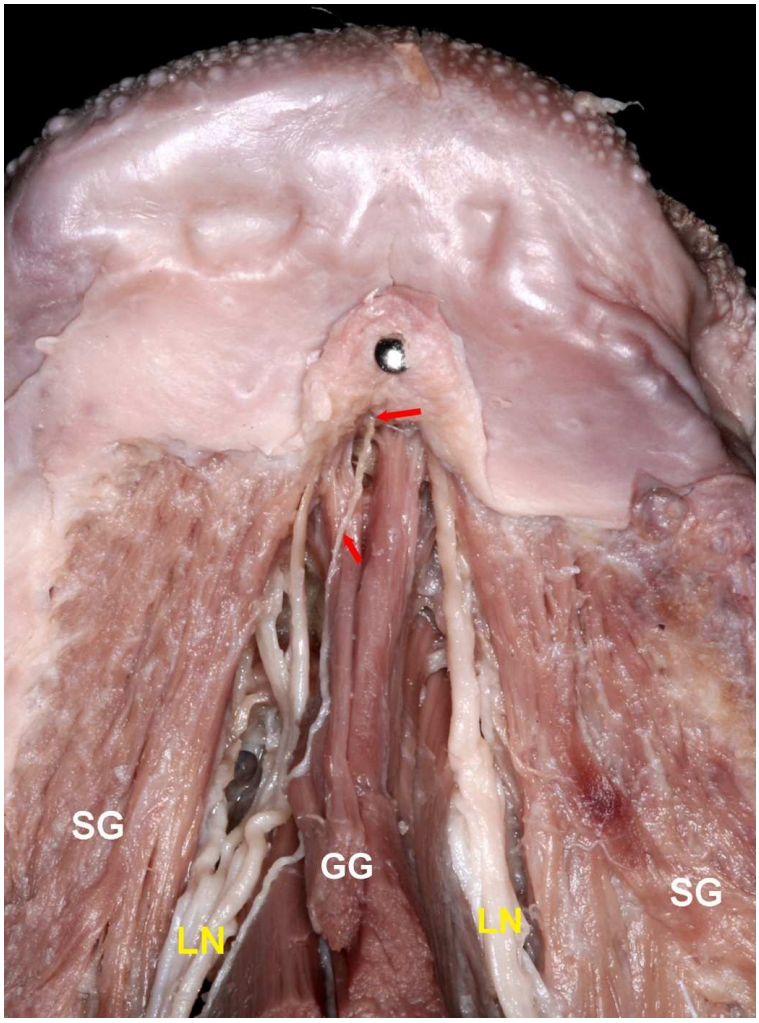

Fig. 3. The twigs (TM) directly innervating to the vental mucosa of the tongue. The specimen belonged to the Type IIb is presented as a vental view. The TM was proceeding medially and reaching the midline of the lingual frenulum. SG, styloglossus; GG, genioglossus; LN, lingual nerve; TM, twigs directly innervting to the ventral mucosa of the tongue.

B. Asymmetry of the lingual nerve course on each sides

The difference in the courses of the mLN between right and left side were shown in 9 tongues (56.3%). The case with TM was found in 6 cases of the 16 specimens (37.5%), and 4 of these 6 specimens had TM on only one side (66.7%). The asymmetry of the presence of the TM were shown in 6 specimens (37.5%) (Table 2).

Table 2. Asymmetry of the anatomical patterns of the lingual nerve between right and left side

Observed items	Patterns of each side		
	Measurement Units (100%)	Same	Difference
Course of the lingual nerve	Observed 32 cases (from 16 tongues)	43.8%	56.3%
Presence of the mucosal twigs (TM)	Observed 32 cases (from 16 tongues)	62.5%	37.5%
Distribution of the TM	Detected 6 tongues	33.3% (Present in each side)	66.7% (Present in only one side)

2. Distribution of lingual nerve courses on the tongue tip

The nerve distribution was visualized by Sihler's nerve staining and it was shown that the main branch of the mLN was inserted to the SS and then they were traveling medially (Fig 4). The main branch of the mLN was terminated by reaching the tongue tip, and the branches of each side constituted the nerve network at the middle of the tongue tip. There was no

interconnection of the LN branches of each side prior to reaching the tongue tip. However, in some cases, the communicating twigs were present at the tongue tip region. Some additional twigs were branched from the main branches and travelled more laterally than the main branches. These additional twigs also reached the tongue tip region and were distributed in that region.

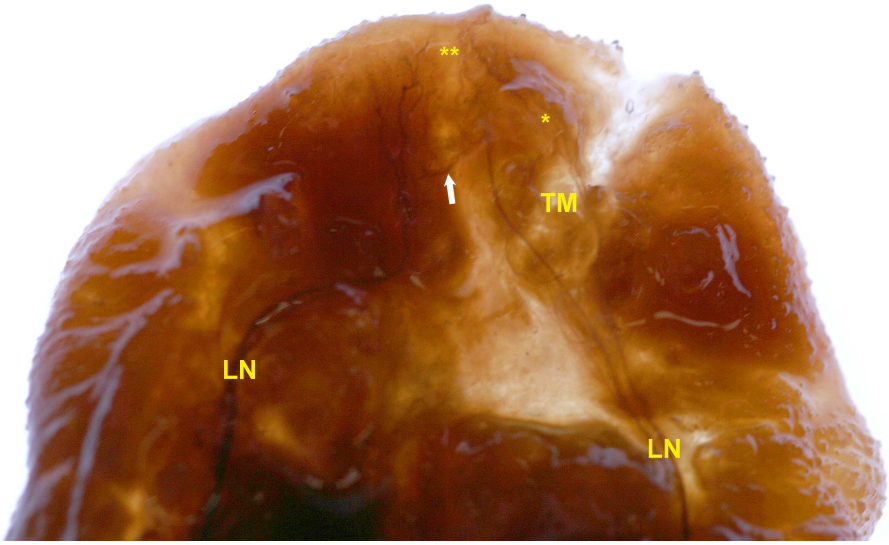

Fig. 4. The innervation of the LN to the tongue which was visualized by modified Sihler's nerve staining. The LN of right and left side is approaching each other and there is an anastomosis of the LN of each side (arrow). The twigs (TM) directly innervating to the mucosa is proceeding laterally and also reach the tongue tip (*). The branches of the LN of each side formed the nerve plexus at the tongue tip (**). LN, lingual nerve; TM, mucosal twigs directly innervting to the ventral mucosa of the tongue.

Ⅳ. DISCUSSION

The prevalence of ankyloglossia (tongue-tie) was reported from 4.2 to 10.7% in the Unites States and United Kingdom (Segal et al., 2007) respectively. Frenectomy is a recommended procedure for patients with ankiloglossia and due to its invasiveness, in-depth anatomical knowledge of the sub- and intra- lingual course is required. Generally, lingual nerve injury causing numbness, paresthesia, and dysgeusia of the tongue usually occurs during invasive dental interventions such as the extraction of the third molar (Graff-Radford and Evans, 2003; Brimacombe et al., 2005; Tolstunov, 2007) and thus, have made many researchers study the anatomy of the LN in the retromolar area comprising the lingual mucosa at the molar region (Lauretano et al., 1997; Behnia et al., 2000; McGeachie, 2002; Graff-Radford and Evans, 2003; Kim et al., 2004, Erdogmus et al., 2008). For this purpose, it seems indispensable to have a thorough knowledge of the topography of the sub- and intra-lingual course at the ventral region of the tongue for performing safety surgical intervention such as a frenectomy.

Due to the intermeshing of the tongue muscles, it is impossible to observe the intra-lingual course of the LN by dissection (Toure et al., 2005). Therefore, we used modified Silher's nerve staining which enabled the nerve to be visualized without marked modification of the position. The modified Sihler's nerve staining was used for the research of the innovation of the larynx and canine tongue up to date (Sanders et al., 1993; Wu and Sanders, 1996; Wu and Sanders, 1998; Wu and Sanders, 1999; Toure et al., 2005). Toure et al. (2005) and Zub et al. (2004) reported the distribution of the intralingual course of the LN by using modified Sihler's nerve staining, however they did not provide the clinical criteria for surgical treatment. Toure et al. (2005) reported that the

LN pierced into the tongue, and divided into lateral, intermediate and medial branches after receiving an anastomosis from the anterior branch of the hypoglossal nerve, and this was in accordance with the findings from Zub et al. (2004). In the present study, we found that at the tongue tip region, the LN branches of right and left side were closely approaching each other, and eventually distributed to the middle of the tongue tip. There was an anastomosis of the LN of each side at the middle of the tongue tip and with the use of Silher's staining, TM was detected in also reaching the tongue tip (Fig. 2). Based on these findings, it may be postulated that the numbness of the tongue tip may result from injuries inflicted on the intra-lingual twigs and TM of the LN and the possibility exists that the nerve injury may be occurred by an incision extending to the tongue tip.

Since, the nerve twigs of the LN at the ventral tongue region did not exceed the midline at the frenulum region, it may be safe to make the incision on the midline in the ventral mucosa. Furthermore, we were able to strip off the mucosa that possessed the LN. To reduce the likelihood of injuries during surgical procedures, the clinician may after making a vertical incision on the ventral mucosa of the tongue use this knowledge of LN distribution course and take precautions to avoid inflicting any type of surgical trauma or injury. However, the cases with the TM in 37.5% while disregarding the courses of the LN, and the Type III was found as the LN proceeded vertically in 18.8% and, the transverse incision or Z-frenuloplasty was capable of damaging the nerve twigs in the case of vertical course (Heller and Gabbay, 2005). Segal et al. (2007) mentioned that the frenectomy was a safe intervention for the ankyloglossia. In our study, the most common pattern of the LN course was the curved type (65.6%) which in cases of frenectomies can be performed without causing serious nerve damage. Also the straight type (15.6%) was evaluated as the safest pattern in the frenuctomy. This supports the conclusion

by Segal et al. (2007). However, the TM was present in straight and curved type which constituted 25.1%. Although the incidence of numbness induced by nerve injury during the frenectomy was not clear, the existence of TM may suggest that a nerve injury may result from careless and inadequate manipulations during the frenectomy, such as the severe impingement by surgical forceps, untidy incision at the upper area of frenulum near the tongue tip.

From the information obtained from the asymmetry of the LN course (56.3%) and the presence of the TM (37.5%), it may be postulated that the confirmation of the LN topography on one side would not guarantee that same was present in anatomy of the LN on the other side. Moreover, four of the six tongues, in which we detected TM, had TM on only one side.

Since the tongue in viable patients is dynamic and constantly moving, it is difficult to establish the landmark for measurement of the tongue structure such as the LN course, the proceeding patterns of the LN and mucosal distribution which we provided in this study may serve as an invaluable guide to perform surgical interventions such as frenectomy or frenuloplasty safely.

Ⅴ. CONCLUSION

The conclusions of this study are as follows.

1. It may be postulated that the numbness of the tongue tip may result from injuries inflicted on the intra-lingual twigs and TM of the LN and the possibility exists that the nerve injury may be occurred by an incision extending to the tongue tip.

2. To reduce the likelihood of injuries during surgical procedures, the clinician may after making a vertical incision on the ventral mucosa of the tongue use this knowledge of LN distribution course and take precautions to avoid inflicting any type of surgical trauma or injury.

3. The existence of TM may suggest that a nerve injury may result from careless and inadequate manipulations during the frenectomy, such as the severe impingement by surgical forceps, untidy incision at the upper area of frenulum near the tongue tip.

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Abstract (in korean)

혀 배쪽에서의 혀신경 주행과 분포; 혀주름띠 절제술에서의 해부학적 고려

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우 용 제

이 연구의 목적은 혀신경의 혀 배쪽에서 혀 속 및 혀 바깥 주행을 밝혀 혀 주름띠 절제술과 같은 외과적 술직의 임상적 자료를 제공하기 위함이다. 혀신경의 주행과 분포를 관찰하기 위하여 한국인 혀 반쪽 16쪽을 미세해부 하였고 6쪽을 실러 (Sihler) 염색 처리하였다. 이를 위해 혀신경을 그 주행에 따라 5개로 분류하였고, 혀끝에서의 분포를 확인하였다. 혀신경 주행의 분류를 위해 붓혀근과 턱끝혀근이 만나는 선을 기준점으로 설정하였다. 또한 혀밑 부위의 점막으로 바로 분포하는 작은 가지 (점막가지)의 유무를 혀신경 주행 및 분포 분류에 고려하였다. 점막가지가 없는 경우 9.4%에서 곧은 양상, 46.9%에서 휘어져 들어가는 양상 그리고 18.8%에서 수직으로 들어가는 양상을 보였다. 점막가지가 있는 경우 6.3%에서 곧은 양상, 18.8%에서 휘어져 들어가는 양상을 보였다. 실러 염색을 통해 혀신경의 혀 끝에 분포하는 것을 확인할 수 있었다. 이 연구를 통해 혀 배쪽 부위에서의 수술적 조작에 의해 혀끝마비와 같은 부작용을 줄 수 있음을 확인하였으며, 이 부위의 다양한 외과적 술식을 위한 해부학적 근거를 제공하였다.

핵심되는 말 : 혀신경, 혀끝, 혀주름띠, 혀주름띠 절제술, 혀주름띠 성형술, 실러 염색