

Lingual Nerve Course and Its Communication with Hypoglossal Nerve: Variations in Cadavers in Western India

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Abstract

Background: Location and variations in branching pattern of lingual nerve makes it vulnerable to injury in various oral and dental surgical procedures. Awareness of variations in distribution pattern will reduce the chances of injury to lingual nerve and post-operative complications in excision of ranulas, extraction of third molar tooth, sub mental endotracheal intubation and during difficult suspension laryngoscopy. Present study was undertaken to describe the course, morphology and variations of lingual nerve in infra-temporal and submandibular regions and to find out communication(s) if any with hypoglossal nerve. **Methods:** Head and neck dissection was performed in fifteen formalin fixed cadavers after obtaining due permission from institutional ethics committee. Length and diameter of each lingual nerve was measured. Morphology of lingual nerve was studied to find its communicating branches with hypoglossal nerve. **Results:** Significant difference was noted in the length of second part of lingual nerve in males and females ($p < 0.05$). Diameter of lingual nerve at the level of second molar tooth was found as 2.82 mm in males and 2.79 mm in females. Communications between lingual nerve and hypoglossal nerve were found in 6 specimens. In five specimens single communication was found. Three communicating branches (proximal, middle and distal) were found in one specimen between lingual nerve and hypoglossal nerve. Lingual nerve either terminates as a single branch or as multiple branches. **Conclusion:** Present study reports variations in termination pattern of lingual nerve. Multiple extralingual communications with different morphological patterns were observed between lingual and hypoglossal nerve.

Keywords: Communications, Diameter, Length, Lingual Nerve, Variations

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Introduction

The location and variations in branching pattern of lingual nerve makes it vulnerable to injury in various oral and dental surgical procedures. Injury to the nerve can cause paraesthesia, hypoesthesia or even dysesthesia, ipsi laterally in anterior two third part of the tongue[1]. This can lead to impairment in tongue functions like articulation of speech and difficulty in swallowing leading to a negative effect on psychological well-being of patient[2]. Literature is full of evidences that lingual nerve has a highly variable course in oral cavity and in the region of third molar tooth. Anatomical variation of lingual nerve has been identified as a possible cause for postoperative complications in case of lympho-epithelial cyst excision on undersurface of tongue[1]. Lingual nerve injury is reported to be the second most common complication with traditional submandibular gland excision[3]. Lingual nerve is a branch of posterior division of mandibular nerve[4-6]. It is given off just below the foramen ovale[7] and lies anterior to inferior alveolar nerve in infratemporal fossa[8]. It is joined by chorda tympani nerve 1-2 cm below foramen ovale[9]. It runs behind the lateral pterygoid muscle and emerges below its lower border. It then runs downwards and forwards between the ramus of mandible and

medial pterygoid muscle. It then passes below the mandibular attachment of superior constrictor and pterygomandibular raphe to lie below and behind third molar tooth where it is covered by mucosal periosteum only, thus making it more susceptible to injury at this point[9-11]. Further, lingual nerve enters the submandibular region by passing medial to mylohyoid muscle and between submandibular gland and duct[9] before entering the middle of anterior two-third of tongue[12] from its lateral side. As the lingual nerve proceeds anteriorly from the third molar region, it becomes very tortuous and assumes a highly variable relationship near the submandibular duct and gland. This tortuosity helps in mobilization of distal stump to proximal stump during surgical repair[13] and allows neurolysis rather than reconstruction with a graft[14]. Submandibular ganglion is suspended from the nerve on hyoglossus muscle. Many studies have described variations in course and branches of lingual nerve, high up in infra-temporal region like presence of multiple roots of lingual nerve, its connection with inferior alveolar nerve, absence of chorda tympani nerve[15] and variable distance of its bifurcation from foramen ovale[7]. Variations are also seen in its relation to alveolar crest [16], mylohyoid nerve[17,18] medial pterygoid muscle[9] and submandibular duct[19,20] and in termination of the lingual nerve on the lateral edge of tongue[16]. Functionally, lingual nerve carries general sensations from anterior two-third of tongue while hypoglossal nerve supplies muscles of tongue. Many studies described intralingual connectives[12,21,22] between lingual and hypoglossal nerve but only a few have reported extra-lingual communications[7] with hypoglossal nerve. Awareness of variations in distribution

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pattern will reduce the chances of injury to lingual nerve and post-operative complications in excision of ranulas [23], extraction of third molar tooth [24-31], sub mental endotracheal intubation [32] and during difficult suspension laryngoscopy [33]. Present study was undertaken to describe the course, morphology and morphometry of lingual nerve in infratemporal and submandibular regions in western Indian population and to find out communication(s), if any with hypoglossal nerve in submandibular region and near its termination.

Materials and Methods

The present study was conducted in the Department of Anatomy, Banas Medical College & Research Institute, Palanpur, Gujarat after obtaining due permission from Institutional ethics committee (Ref: BMCRI/IEC(H)/Approval/A1/01/2020/9/04/04 dated 04.09.2020). Specimens for the present study were obtained from Banas Medical College & Research Institute, Palanpur, Gujarat and also from Mahatma Gandhi Institute of Medical Sciences and Research Centre, Jaipur, Rajasthan. Informed written consent was obtained from close relatives of all donated bodies to use donated bodies for the purpose of education and research. Head and neck dissection was performed in fifteen formalin fixed cadavers (eight male and seven female). Thirty lingual nerves were dissected in the infratemporal and submandibular regions till their termination in oral cavity. The dissection of infratemporal region was carried out once first year medical students completed the dissection of scalp and face in each cadaver. Coronoid process was cut and the ramus of mandible was split just above third molar tooth, horizontally on either side, in each cadaver. Lingual nerve was identified medial to mylohyoid muscle and was traced back to observe its connection with chorda tympani nerve, at its beginning near foramen ovale. Then, the nerve was

followed forward on hyoglossus muscle till it entered the tongue. Each lingual nerve was measured from its origin to the level of closest proximity to 3rd molar mandibular tooth (1st part), then from 3rd molar tooth to the place where it gives branch to submandibular ganglion (2nd part) and finally from where it gives branch to submandibular ganglion till its entry point in tongue (3rd part). Diameter of each lingual nerve was measured at the level of 3rd molar mandibular tooth. Both measurements were taken using digital Vernier Callipers. Morphology of lingual nerve was studied to find its communicating branches with hypoglossal nerve and terminal branches.

Results

Total thirty lingual nerves (16 in male and 14 in female cadavers) were dissected. Lingual nerves were studied in infratemporal and submandibular regions. Length of three parts of lingual nerve and its diameter were measured. Means of length and diameter values were calculated. Means were compared for both sides and in both sexes using unpaired t-test.

Measurements of lingual nerve

Mean length of lingual nerve was found as 80.06 mm in males and 77.21 mm in females. A significant difference was observed in length of second part of lingual nerve (p<0.05) in males and females (Table-1). This length was measured from the point of closest proximity of lingual nerve to 3rd molar tooth to the place where it gives branch to submandibular ganglion. The mean diameter of lingual nerve was found as 2.82 mm in males and 2.79 mm in females at the level of second molar tooth. No significant difference (p>0.05) was observed in length and diameter of lingual nerve on right and left sides both in males and females.

Table 1: Comparison of length and diameter of lingual nerves found in male and female cadavers

Sr No	Parameter	Sex	No	Mean age (Year)	Mean (mm)	Standard deviation (mm)	Variance (mm ²)	P value
1	1st part of lingual nerve	Male	14	73	39.28571	2.701241066	7.296703297	0.144773922
		Female	12	82	38.41667	1.164500153	1.356060606	
2	2nd part of lingual nerve	Male	14	73	19.71429	1.683794772	2.835164835	0.047171219
		Female	12	82	18.58333	1.621353718	2.628787879	
3	3rd part of lingual nerve	Male	14	73	21.71429	2.127785827	4.527472527	0.102022462
		Female	12	82	20.25	3.829708431	10.93181818	
4	Total length of lingual nerve	Male	14	73	80.71429	4.084277008	16.68131868	0.010711752
		Female	12	82	77.25	3.078517943	9.477272727	
5	Diameter of lingual nerve	Male	14	73	2.876429	0.254123142	0.064578571	0.152292462
		Female	12	82	2.798333	0.100889979	0.010178788	

Terminal branches of lingual nerve: In 25 out of 30 specimens, we found that the lingual nerve is entering into the tongue as single trunk. Two and three terminal branches were present in 2 specimens each. In one specimen, lingual nerve was having 4 terminal branches.

Table 2: Variations in number of terminal branches of lingual nerve on hyoglossus muscle in total 30 specimens as seen in present study

Number of Terminal Branches	Number of Specimens	Percentage
One (Single trunk)	25	83.33%
Two	02	6.67%
Three	02	6.67%
Four	01	3.33%

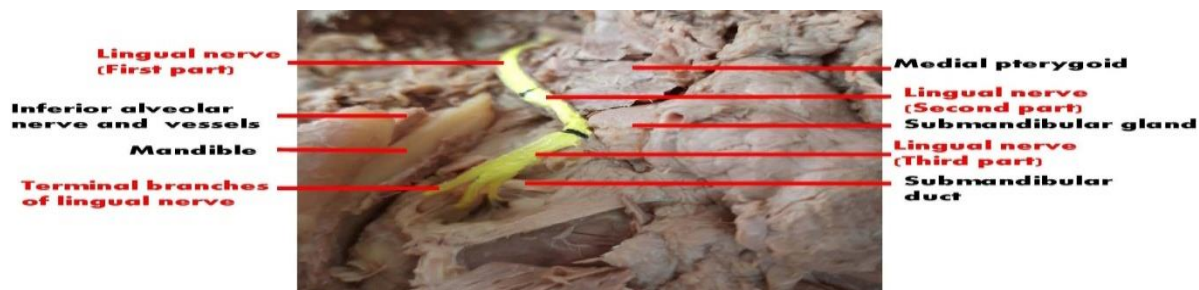


Fig 1: Photograph showing the 1st, 2nd and 3rd part as well as terminal branches of left lingual nerve Communication between lingual nerve and hypoglossal nerve

Communications between lingual nerve and hypoglossal nerve were found in 6 specimens (4 male specimens and 2 female specimens). Communications were detected on right and left both sides equally, three on right side and three on left side. Three communications were found anteriorly in sublingual region (Figure 5) and three were present posteriorly in submandibular region (Figures 3 and 4). In five specimens single communication was found (Table 2). In one specimen of right side in male cadaver (Figure 2), three

communicating branches (proximal, middle and distal) were found between lingual nerve and hypoglossal nerve. In this specimen, length of 1st part of lingual nerve was 45 mm, length of 2nd part of lingual nerve was 20 mm, length of 3rd part of lingual nerve was 21 mm, total length of lingual nerve was 86 mm while the diameter of lingual nerve at the junction of 1st and 2nd part of lingual nerve was 3.22 mm. These communicating branches originated directly from the trunk of lingual nerve.

Table 3: Description of Communications between lingual and hypoglossal nerve as seen in present study

Communications	Laterality	Sex	Location	Origin of communicating branch from	Number of communicating branches
1	Right	Male	Anterior	Trunk of lingual nerve	Three
2	Right	Male	Posterior	Trunk of lingual nerve	Single
3	Left	Male	Posterior	Branch of lingual nerve	Single
4	Left	Male	Posterior	Branch of lingual nerve	Single
5	Right	Female	Anterior	Branch of lingual nerve	Single
6	Left	Female	Anterior	Branch of lingual nerve	Single

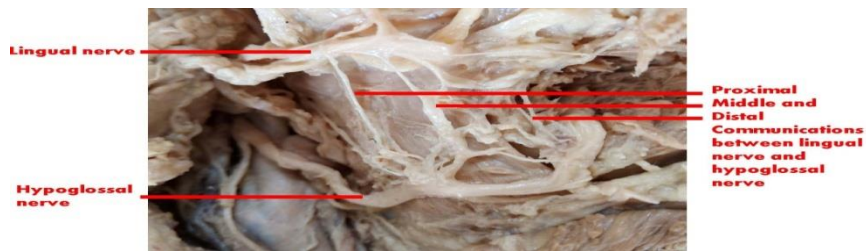


Fig 2: Photograph showing the Proximal, middle and distal communications between right lingual nerve and right hypoglossal nerve in male cadaveric specimen in sublingual region



Fig 3: Photograph showing the communication between right lingual nerve and right hypoglossal nerve in male cadaveric specimen in submandibular region



Fig 4: Photograph showing the communication between left lingual nerve and left hypoglossal nerve in male cadaveric specimen in submandibular region

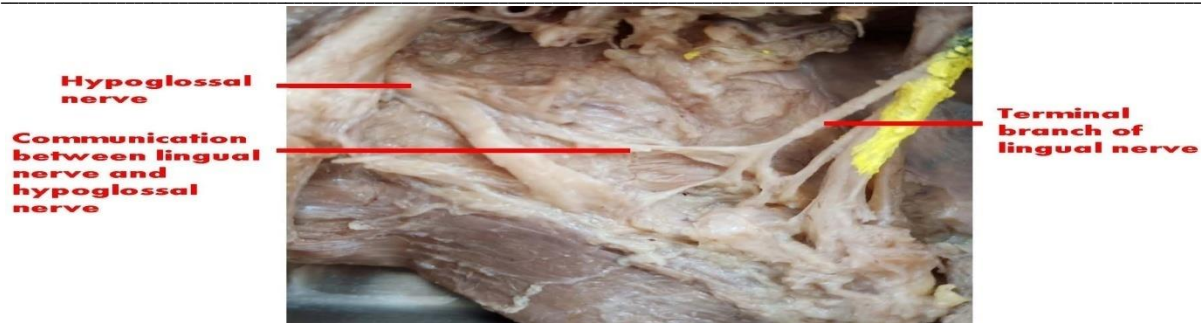


Fig 5: Photograph showing the communication between right lingual nerve and right hypoglossal nerve in female cadaveric specimen in sublingual region

Discussion

The anatomy of lingual nerve is critical for considering the complications of inferior alveolar nerve block and wisdom tooth extraction[36]. In the present study length of lingual nerve was measured from its origin near foramen ovale to the point where it enters the tongue. No significant difference was observed in mean length of lingual nerve in male and female specimens. But a significant difference ($p < 0.05$) was found in length of lingual nerve measured from the point of its closest proximity to 3rd molar tooth to the place where it gives branch to submandibular ganglion (2nd part) in male and female cadavers (Table-1). It may be due to variable tortuosity of lingual nerve as it proceeds anteriorly from the third molar region, it becomes very tortuous and assumes a highly variable relationship near the submandibular duct and gland. This tortuosity helps in mobilization of distal stump to proximal stump during surgical repair[13]. This difference in mean length of 2nd part of lingual nerve could also be attributed to the morphological variations in the size of mandible in male and female cadavers corresponding to the considered bony landmarks. The average length of lingual nerve is not mentioned in most standard textbooks of anatomy[4-8]. Al Amery et al described the mean length of lingual nerve as 25.43 mm on floor of mouth. They measured this length as distance from the deepest point at the angle between ramus and body of the mandible to the point at which the nerve changes its direction towards the tongue in 14 cadaveric specimens. They did not find any significant difference in length with regards to left and right side of cadavers[16]. No significant difference in length of left and right lingual nerves was also detected in present study. Variations in width (diameter) of lingual nerve and its anatomical location[34] have been linked to lingual nerve injury during inferior alveolar nerve block for providing anaesthesia[1]. According to R Pippi et al direct needle injury might result in neurotomesis of lingual nerve because of the relative difference in diameter of needle used for the block (0.45mm) and diameter of lingual nerve (1.84mm)[35]. In the present study mean diameters of lingual nerve were found to be 2.82 mm in males and 2.79 mm in females at the level of 2nd molar tooth. No significant difference was found in diameters in terms of sex or laterality. J Iwanaga et al found the mean diameter of lingual nerve as 2.97mm in twelve formalin fixed Caucasian cadaveric heads[36]. No significant difference was found in diameters of lingual nerve in both sexes and on both sides. Similar results were found in study by Holzle and Wolf[37] in 2004. They found diameter to be 2.7mm in 68 formalin fixed cadaveric heads at the level of last mandibular molar tooth. Kisselbach and Chamberlei[11] in 1984 found it to be 1.86mm at the level of third molar tooth and Zur et al[38] reported 3.5 mm as the mean diameter of trunk of lingual nerve. A variation has been seen in literature with regards to mean diameter of lingual nerve. It may be due to racial differences. Diameter is recognised as a potential risk factor for lingual nerve injury[39] while giving anaesthesia and during oral surgery. Tongue performs certain

complex functions like taste, swallowing and vocalization for which there exists complex interconnections between its sensory and motor nerves[7]. Such communications exist both inside and outside the tongue [40]. Communications of lingual nerve with hypoglossal nerve outside the tongue were observed in the present study. These communications were present only in 20% of total dissected specimens. Fitzgerald [41] et al in 1958 reported lateral lingual-hypoglossal communications in 90% of specimens out of total 40 dissected specimens. All of them were present outside tongue and seen on hyoglossus muscle. H. Shinohara[7] described two kinds of extra-lingual communications between hypoglossal and lingual nerves, the anterior and posterior type. Anterior type was observed in sublingual area near termination of lingual nerve and posterior type in submandibular region. In the present study anterior and posterior type communications, each were observed in equal number (11.54%) of specimens. Shinohara et al reported more posterior type communications (56.27%) than anterior type (26.6%) in Japanese cadaveric specimen. The observed difference in occurrence of communications between lingual and hypoglossal nerves between present study and studies done by Fitzgerald and H. Shinohara [7,41] could be attributed to racial variations. However the sample size in these studies and in present study is very small so the results cannot be generalised to the entire population. In the present study the communication of lingual nerve with hypoglossal nerve was detected through a single branch of lingual nerve arising from a branch which was directly coming from trunk of lingual nerve except in two specimens. In these two specimens communicating branches were arising directly from trunk either as a single branch or multiple branches. Similar findings were reported by Y. Sakamoto⁴² who found multiple communicating rami emerging between hypoglossal and lingual nerves. Author detected that these rami were arising from a branch coming from main trunk of lingual nerve. Author also found rami emerging from a communicating branch given by one of the branches of lingual nerve. Shimotakahara[40] reported plexiform communication between lingual and hypoglossal nerves both inside and outside the tongue. He further found communicating loops between lingual and hypoglossal nerves outside the tongue on hyoglossus muscle. In the present study similar communicating loops were observed in one specimen outside the tongue. Studies using Schillers staining[12,21,22,38] have demonstrated numerous intra-lingual connections and it appears there are more intramuscular communications than external communication[42]. Functionally, these communicating channels appear to be sensory-motor in nature. But study by Mu and Sanders in 2010 revealed that lingual nerve conveys motor fibres of trigeminal root to superior and inferior longitudinal lingual muscles[43] along with proprioceptive fibres[40]. Similarly hypoglossal nerve communicates with vagus nerve and sympathetic chain and may contain autonomic fibres. This difference in constitution of communicating rami might be the cause behind the presence of variations in their bifurcation[42]. Awareness of these

communicating channels is important for restoring the mobility of tongue after glossectomy in cases of benign and malignant lesions[40]. Knowledge of morphology of lingual nerve is also required during treatment of refractory tongue neuralgia[8].Lingual nerve either terminates as a single or multiple branches. It divides into terminal branches on hyoglossus muscle when it enters tongue. Nerve forms different morphological patterns. Rusu[21]et al observed two morphological patterns. The single nerve trunk and two terminal branches were found in equal number in 12 cadaveric heads. Al-Amery et al found four patterns. The lingual nerve ended up as one, two, three or four terminal branches[16].They observed two terminal branches as the most common pattern in 7 out of their 14 cadaveric specimens. In the present study, lingual nerve entered into tongue as a single trunk in majority of specimens (25specimens). Lingual nerve dividing into two, three or four terminal branches was also found in present study(Table-2).These differences in the morphological pattern might be because of the regional differences. Moreover the sample size in all above studies and in the present study is small so results cannot be generalised to the entire population. Some of the studies[12,38]on intra-lingual topographic pattern of lingual nerve demonstrated that lingual nerve reaches tongue postero-laterally and then divides in two subdivisions and then each subdivision divides further in thinner branches. It might be possible that single nerve trunk observed in majority of specimens in present study having the same fate as demonstrated by Iwanaga et al [12] and Zur KB[38]

Conclusion

Lingual nerve either terminates as a single branch, or as multiple branches as observed in the present study. Lingual nerve can also terminate by forming a loop on hyoglossus muscle as also observed in the present study. The present study reports multiple extralingual communications between lingual and hypoglossal nerve. Comprehension and understanding of course, morphometry, variations in communication of lingual nerve with hypoglossal nerve and termination pattern of lingual nerve will be helpful for the oral and dental surgeons while doing procedures in this region and reduce the chances of postoperative complications caused by lingual nerve injury[44]

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