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## Distribution of the hypoglossal nerve at the base of the tongue and its clinical importance in radiofrequency ablation therapy

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**Aim:** To identify the course of the hypoglossal nerve at the base of tongue and to determine a safe area for the placement of radiofrequency ablation therapy (RAT) probes to protect the nerve trunk from any damage.

**Materials and methods:** Anatomical structures located at the base of the tongue were investigated in 10 cadaveric human half-heads. On the base of our landmarks, which are clinically important sign points, measurements were made.

**Results:** The safe area was found to be: in the transverse plane, the 1/2 medial part of the half-tongue between the lateral edge and the foramen caecum of the tongue, and in the vertical plane, a 14.5-mm depth. Despite the presence of minor branches of the hypoglossal nerve in this area, we think that the trunk of the nerve would be preserved.

**Conclusion:** We suggest that the landmarks that we determined to avoid motor deficit of the tongue will be helpful for clinicians during RAT to the tongue base.

**Key words:** Hypoglossal nerve, radiofrequency ablation, tongue, snoring, obstructive sleep apnea

### 1. Introduction

The tongue base is a clinically important area because of its close relationship with clinical situations such as obstructive sleep apnea syndrome, dysphagia, and snoring (1–5). One of the major anatomic structures that may be injured during clinical procedures of the tongue base is the hypoglossal nerve, which is the motor nerve of the tongue. It innervates all the muscles of the tongue, except the palatoglossus (2,6). Since the hypoglossal nerve also has a major role in speech control and swallowing, in addition to the motor control of tongue muscles, injury of the hypoglossal nerve may cause palsy of the tongue, leading to problems with pronunciation and deglutition. Severe and bilateral trauma of the nerve can affect the protrusion motion of the tongue, causing it to fall backwards, possibly resulting in airway obstruction (7).

Radiofrequency ablation therapy (RAT) is a treatment method in which heat energy is applied to the tissues with special probes to make a volume reduction induced by thermic lesions and subsequent scarring of the tissue (8,9). RAT to the tongue base was first introduced as a minimally invasive technique in the treatment of snoring

by Powell et al. (9). In their pilot study, MRI measurements were performed, resulting in a remarkable reduction of soft tissue of approximately 17% in volume. Recently, it has been a popular treatment method for diseases in which the tongue base is bigger than the optimal size, causing obstruction in the upper airway. A standardized coagulation effect on the tongue base tissue is extremely important, as the hypoglossal nerve and neurovascular bundle may be damaged if lesions grow too large. During such invasive procedures, determinant of tongue function depends on the ability to preserve one or both hypoglossal nerves (10). Friedman et al. (11) reported that 6 out of 96 patients had developed hypoglossal nerve palsy in their study. Considering these facts, we aimed to demonstrate the safe area of the tongue base for RAT with some anatomical landmarks and also to identify the entrance points of the hypoglossal nerve to the tongue, the intralingual course of the nerve, and its relation to the lingual nerve.

### 2. Materials and methods

The hypoglossal nerve was studied on 10 sides of 7 male formalin-fixed adult Caucasian cadavers whose ages

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ranged between 55 and 74 years. The heads of the cadavers were divided into right and left sides by sagittal dissection, which passed through the median line of the tongue (from apex to foramen caecum of tongue). Microdissections were performed on the internal side of the mandible, near the lateral edge of the tongue, from the retromolar trigone to the anterior part of this region under magnifications of a Carl-Zeiss OPMI1-FR surgical microscope.

The intralingual course and distribution of the hypoglossal nerve, and its relationship with the lingual nerve and artery and the submandibular duct, were demonstrated. Measurements were made to demonstrate the localization of the hypoglossal nerve at the tongue base region and its relation to the tongue and other adjacent structures with a digital caliper with 0.1-mm gradations. Measurement points are listed in the Table and shown in Figure 1.

### 3. Results

Before entering the tongue, the neurovascular structures had a configuration between the mylohyoid and hyoglossus muscles such that the lingual nerve lay uppermost, the submandibular duct was below it, and the hypoglossal nerve lay lowermost. Additionally, the submandibular duct crossed the lingual nerve and the submandibular ganglion was above the lingual nerve, posterior to the sublingual gland (Figure 2). Multiple extralingual connections between the hypoglossal and lingual nerves, posterior to the sublingual gland and posterosuperior to the common tendon of the digastric muscle, were observed in all specimens (Figure 3). The hypoglossal nerve entered the tongue between the hyoglossus and genioglossus muscles, followed the fibers of the genioglossus muscle, and spread up in a fan-shape to the posterior, superior, and anterior

directions in the tongue (Figure 4).

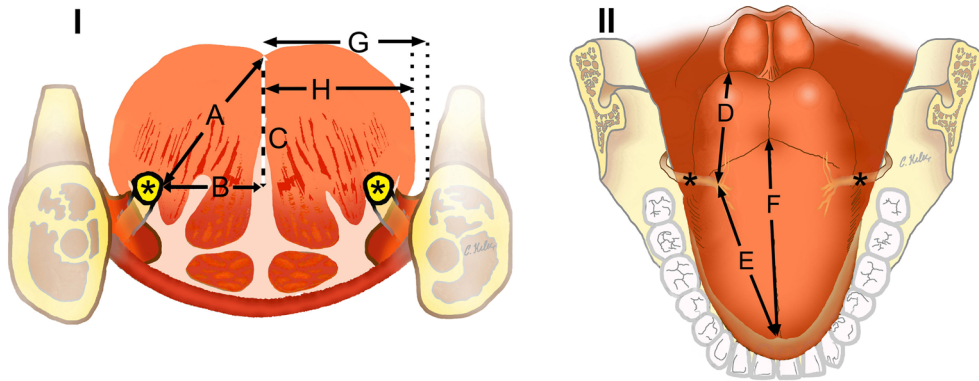
The entrance point of the nerve is near the point between the 1/3 lateral and 2/3 medial parts of the tongue half-side. There was no case in which the trunk of the hypoglossal nerve lay in the 1/2 medial part of the tongue half-side. The nearest distance between the entrance point and the foramen caecum of the tongue was 11.86 mm in a sample whose width of the half-tongue was 22.14 mm. The mean value of the depth of the nerve trunk from the foramen caecum of tongue was 18.07 mm, and the most superficial value was at a depth of 14.56 mm. In all cases except one, the entrance point of the nerve to the tongue was anterior to the foramen caecum of the tongue (Table). According to these results, to avoid injury to the main trunk of the hypoglossal nerve during application of RAT probes, the medial 1/2 of the tongue-half in transverse plane at a depth of 14.5 mm in the vertical plane is the safe area.

### 4. Discussion

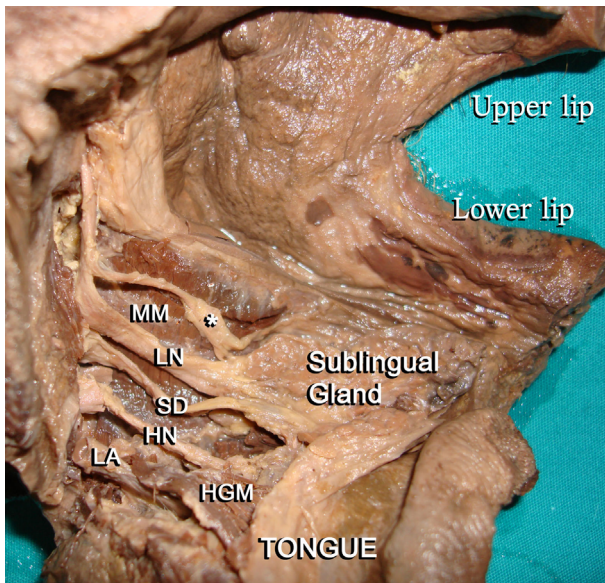
A thorough anatomical knowledge of the tongue base and related neurovascular structures, especially the hypoglossal nerve, is required for many otorhinolaryngological surgical applications. For this reason, this region has been subject to previous studies in which there were several descriptions about the course and the topographic relationships of the hypoglossal nerve (2,12,13). In agreement with our description of the configuration of the hypoglossal nerve and adjacent neurovascular structures before entering the tongue, Bademci and Yasargil (13) also suggested that the lingual nerve lay uppermost. Below the lingual nerve was the submandibular duct and the hypoglossal nerve lay lowermost. Additionally, the submandibular duct crossed the lingual nerve.

**Table.** Distances between anatomic landmarks.

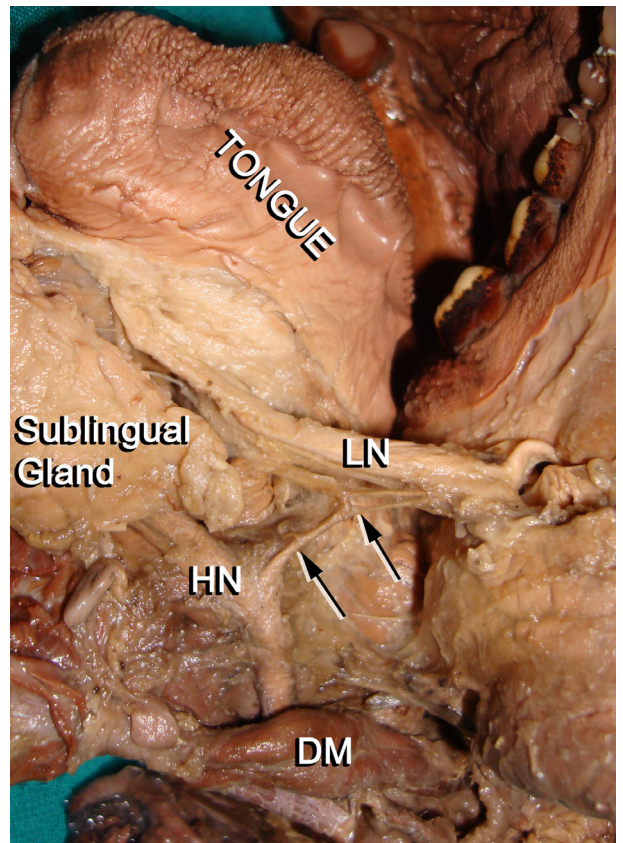
Measured distances	Mean $\pm$ standard deviation (mm)	Range (mm)
A: Oblique distance between the foramen caecum of the tongue and the entrance point of the nerve to the tongue	25.96 $\pm$ 4.55	20.7–32.0
B: Transverse distance between the foramen caecum of the tongue and the entrance point of the nerve to the tongue	14.20 $\pm$ 2.37	11.9–18
C: Vertical distance between the foramen caecum of the tongue and the entrance point of the nerve to the tongue	18.07 $\pm$ 3.82	14.6–23
D: Distance between the attachment point of lateral glossoepiglottic plica and the entrance point of the nerve to the tongue	24.78 $\pm$ 3.94	18.7–31.4
E: Distance between the entrance point of the nerve to the tongue and mentum	39.54 $\pm$ 5.79	32.3–50.3
F: Distance between the foramen caecum of the tongue and mentum	53.29 $\pm$ 5.04	48.1–59.4
G: Distance between the foramen caecum of the tongue and internal surface of the mandible	30.61 $\pm$ 3.95	26.1–35
H: Width of the tongue half-side at the level of the foramen caecum of the tongue	22.26 $\pm$ 3.14	18.1–25.4



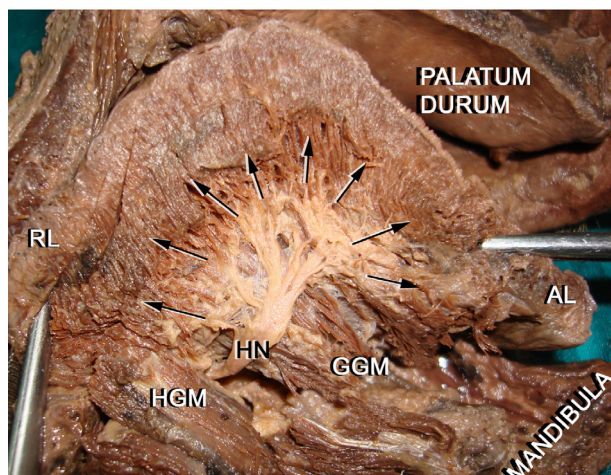
**Figure 1.** Schematic drawing of the measurement points. **I:** Coronal section of the tongue; **II:** Position of the tongue in the mouth and schematic localization of the hypoglossal nerve. **A:** Oblique distance between the foramen caecum of the tongue and the entrance point of the nerve to the tongue; **B:** transverse distance between the foramen caecum of the tongue and the entrance point of the nerve to the tongue; **C:** vertical distance between the foramen caecum of the tongue and the entrance point of the nerve to the tongue; **D:** distance between the attachment point of lateral glossoepiglottic plica and the entrance point of the nerve to the tongue; **E:** distance between the entrance point of the nerve to the tongue and mentum; **F:** distance between the foramen caecum of the tongue and mentum; **G:** distance between the foramen caecum of the tongue and the internal surface of the mandible; **H:** width of the tongue half-side at the level of the foramen caecum of tongue; \*: hypoglossal nerve.



**Figure 2.** Configuration of the neurovascular structures before entering the tongue from the internal aspect of left side (the tongue was separated from its normal position to the inferior direction). Note that the lingual nerve lay uppermost; below it was the submandibular duct, and the hypoglossal nerve lay lowermost. HN: Hypoglossal nerve; LN: lingual nerve; LA: lingual artery; SD: submandibular duct; MM: mylohyoid muscle; HGM: hyoglossus muscle; \*: submandibular ganglion.



**Figure 3.** Extralingual connections between the left hypoglossal and lingual nerves (arrows). HN: Hypoglossal nerve, LN: lingual nerve, DM: digastric muscle.



**Figure 4.** Intralingual distribution of the right hypoglossal nerve (arrows). The hypoglossal nerve followed the fibers of the genioglossus and spread up in a fan-shape. HN: Hypoglossal nerve, HCM: hyoglossus muscle, GGM: genioglossus muscle, RL: radix lingua, AL: apex lingua.

Earlier studies have demonstrated the intralingual and extralingual neural connections between hypoglossal and lingual nerves (2,12,14–16). Saigusa et al. (14) found extralingual connections in 10 of 12 specimens (83%), in which the hypoglossal nerve gave off to the lingual nerve beyond the region where the hypoglossal nerve branched to the hyoglossus muscle and connected beyond the submandibular ganglion of the lingual nerve. Fitzgerald and Law (12) found lateral extralingual connections in 90% of their samples, and Mu and Sanders (2) observed extralingual connections in all of their specimens. We found these neural connections between the hypoglossal and lingual nerves in a multiple formation in all specimens (Figure 3). Despite the fact that the function of these connections is still unknown, Fitzgerald and Sachithanandan (15) suggested that these anastomoses could play a role in lingual proprioception through the median of the hypoglossal nerve from the most distal fibers of the hypoglossal and lingual nerves. We believe that these kinds of neural connections may play a role in neurosurgical procedures such as neurotization, flap procedures, and the surgical treatment of hypoglossal nerve palsy.

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The hypoglossal nerve enters the tongue inferolaterally (2,10,17). According to Touré et al.'s (16) study on 6 human tongues with Sihler coloration technique, the hypoglossal nerve penetrated into the tongue at the junction between the posterior quarter and anterior three-quarters, with an obliquely ventral and medial course, and from its entry into the tongue it divided into a bunch of 8 first-order branches. Mu and Sanders (2) also suggested that the trunk of the nerve coursed anteromedially after entering the tongue. However, we observed that the nerve followed the fibers of the genioglossus and spread up in a fan shape in the posterior, superior, and anterior directions. Bademci and Yasargil's (13) results were in agreement with our findings on this issue.

There were some measurements of the neurovascular structures of the tongue base in previous studies (10,18). Lauretano et al. (10) dissected 10 cadaver heads to determine the position of the neurovascular bundle of the hypoglossal nerve and lingual artery with respect to soft tissue and bony landmarks at the tongue base. Their results indicated that the position of the tongue base neurovascular bundle is significantly inferior and lateral, by 27 mm inferior and 16 mm lateral, to the foramen caecum of the tongue; 9 mm superior to the hyoid bone; and 22 mm medial to the mandible. The distance of the hypoglossal nerve to the tongue surface was measured as  $22.21 \pm 2.22$  mm by Jiang et al. (18). However, in our study, a case was demonstrated in which the nerve trunk was at 14.56 mm depth. This possible superficial course of the hypoglossal nerve must be considered during RAT and also limits the safe area of the tongue base during RAT. In view of our measurements, we suggest that the safe area during application of the probes in RAT for avoiding any injury to the main trunk of the hypoglossal nerve is the medial 1/2 of the tongue-half in the transverse plane and at a depth of 14.5 mm in the vertical plane. Even though there are many minor nerve fibers in this safe area, we think that the main trunk of the hypoglossal nerve will be preserved because of its fan-shaped course.

To avoid any motor deficit, we suggest that the safe area is the 1/2 medial part of the half-tongue in the transverse plane between the lateral edge and the foramen caecum of the tongue and vertically at a depth of 14.5 mm. The measurements we made would be a guideline to the position of the hypoglossal nerve in any surgery in this region.

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