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Grado en Odontología

TONGUE MOVEMENTS DURING MASTICATION, EFFECTS OF A LESION IN THE LINGUAL NERVE

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List of Abbreviations

◦ CN VII	◦ Cranial Nerve 7- Facial Nerve
◦ CN IX	◦ Cranial Nerve 9- Glossopharyngeal Nerve
◦ CN X	◦ Cranial Nerve 10- Vagus Nerve
◦ CN XII	◦ Cranial Nerve 12- Hypoglossal Nerve
◦ CFG	◦ Cineradiography
◦ Ct	◦ Chorda Tympani
◦ EMA	◦ Electromagnetic Articulometer
◦ EPG	◦ Electropalatography
◦ Gang	◦ Submandibular Ganglion
◦ IAN	◦ Inferior Alveolar Nerve
◦ ILM	◦ Inferior Longitudinal Muscle
◦ LB/Bu	◦ Long Buccal Nerve
◦ LN	◦ Lingual Nerve
◦ Me	◦ Mental Nerve
◦ MRI	◦ Magnetic Resonance Imaging
◦ My	◦ Mylohyoid Nerve
◦ NCBI	◦ National Centre for Biotechnology Information
◦ NLM	◦ National Library of Medicine
◦ SLM	◦ Superior Longitudinal Muscle
◦ TM	◦ Transverse Muscle
◦ US	◦ Ultrasonography
◦ VFG	◦ Video Fluorography
◦ VM	◦ Vertical Muscle
◦ V_3	◦ Mandibular Nerve
◦ XRMB	◦ Xray Microbeam

RESUMEN

La naturaleza de los movimientos linguales durante la masticación se basa en la anatomía básica de la lengua, su inervación, trayectoria y variedades de musculaturas, que desempeñan un papel específico en la masticación. Esta disertación fue escrita con el propósito de describir cómo la naturaleza del movimiento de la lengua influye en el proceso de masticación, en la distribución del bolo y en la deglución por igual. Se prestó especial atención a cómo se vería afectada la lengua ante la aparición de una lesión en el nervio lingual. Los experimentos realizados por The Visible Human Project contenidos en The National Library of Medicine (NLM), incluyeron un registro VFG lateral de 16 pacientes sanos que consumían alimentos sólidos para mostrar una correlación entre la lengua y el complejo hiomandibular durante la masticación. Los dibujos que Abd-El-Malek produjo para representar el papel de la lengua en la masticación y la deglución fueron la base de la investigación anatómica, que Hiiemae y Palmer utilizaron con los avances tecnológicos a través de CFG / VFG, para observar los movimientos de la lengua con mayor detalle. Se observó que los movimientos linguales durante la masticación transportaban los alimentos y los mantenían en la superficie oclusal para su procesamiento y, posteriormente, formaban el bolo durante la alimentación. Se utilizaron grabaciones de cámara VFG, el 70% de los 224 ciclos registrados observaron una secuencia cronológica, viendo así en detalle, una relación entre los movimientos de la lengua y la mandíbula durante la masticación. El NLM proporcionó la base para la anatomía, fisiología y trayectoria del nervio lingual. Los efectos de la lesión del nervio lingual se presentaron y clasificaron de acuerdo con los factores de riesgo individualizados y las diferencias se consideraron los principales predictores de los efectos de la lesión del nervio lingual. Los concequencias de una lesión del nervio lingual fluctuaron debido a diferencias en el mecanismo de la lesión, la etiología, la duración de la lesión del nervio y los síntomas del paciente. La

sintomatología común presentada por los sujetos fue: anestesia, parestesia, disestesia o hipoestesia, cambios en los patrones del habla, dolor, sensación de ardor, babeo y morderse la lengua.

ABSTRACT

The nature of lingual movements during mastication is built upon the basic anatomy of the tongue, its innervation, trajectory and an assortment of musculature, that all play a specific role in mastication. This dissertation was written with the purpose of describing how the nature of the tongue's movement influences the mastication process, thus in turn bolus distribution and deglutition alike. A specific focus was given to observing how the tongue would be affected upon the apparition of a lesion to the lingual nerve. Experiments conducted by The Visible Human Project contained in the National Library of Medicine (NLM), included a lateral VFG recording of 16 healthy patients consuming solid foods to show a correlation between the tongue and the hyomandibular complex during mastication. The drawings Abd-El-Malek produced to depict the tongue's role in mastication and deglutition were the foundation for anatomical research, that Hiiemae and Palmer used with advancements in technology through CFG/VFG, to observe tongue movements in greater detail. Lingual movements during mastication were seen to transport food and maintain it on the occlusal surface for processing, and subsequently forming the bolus during feeding. Using VFG camera recordings, 70% of the 224 cycles recorded observed a chronological sequence, hence perceiving in detail, a relationship between tongue and jaw movements during mastication. The NLM provided the basis for the lingual nerve anatomy, physiology and trajectory through which the effects of lingual nerve injury were presented and classified accordingly with individualized risk factors and differences being deemed the main predictors for the effects of lingual nerve injury. The consequences of a lingual nerve lesion fluctuated due to differences in the mechanism of injury, the aetiology, the duration of the nerve injury and the patient's symptoms. Common symptomatology presented by subjects were: anaesthesia, paraesthesia, dysesthesia or hypoesthesia, changes in speech patterns, pain, burning sensation, drooling and tongue biting.

INTRODUCTION

Mastication is defined as the rhythmic, sequential chewing process through which food is broken down by teeth, thus increasing the foods surface area, to assist ingestion (1). It is often regarded as the first stage of digestion, since mastication and the tongue movements involved, provide the kinematic and mechanical scaffold whereby a bolus is produced and subsequently swallowed (2). The mammalian tongue plays an instrumental role in ingestion, using a multiplicity of movements to complete its function. It moves ingested food distally, across the oral cavity from the incisors to the posterior dentition to be chewed, and then to the pharynx for bolus formation and eventual deglutition (3). As food reduction proceeds, the tongue continuously maintains and reforms the bolus against the hard palate and lingual tooth cusps. A series of coordinated jaw movements follow, as well as the manipulation of the tongue through protraction, elongation, retraction and widening (2). Regardless of its complex multifunction, the tongue has recently been labelled a digestive organ above all due to it abetting food transport during mastication and facilitating swallowing (4), even though tongue positioning holds an imperative function in respiration, through its relation to the posterior pharyngeal wall. Furthermore, it is instrumental in the vocalisation of speech and taste through the chemoreceptors and mechanoreceptors located on the tongue surface. This in turn senses the nature and textures of the food, even serving to avert the ingestion of harmful substances. The tongue is by no means the most powerful muscle in the body, despite this, it has the greatest stamina due to its continual use for mastication, and phonation without the appearance of fatigue. It is an entirely voluntary muscle that has been referred to as a muscular hydrostat, due to the intrinsic tongue muscles being the only muscles in the human body that can work independent from the bones of the skeleton (5).

Anatomy of the Tongue

The very nature of the movements of the tongue during mastication, is built upon the basic anatomy of the tongue, as its limitations will give us an implication of the movements to follow.

The tongue is composed of striated muscles and occupies the floor of the mouth, enclosed in an epithelium. A multitude of papillae and taste buds distributed along its surface with approximately, 8 to 12 circumvallate papillae organized in an inverted V shape separating the anterior two thirds from the posterior one third of the tongue (4), as seen in **Figure 1.**

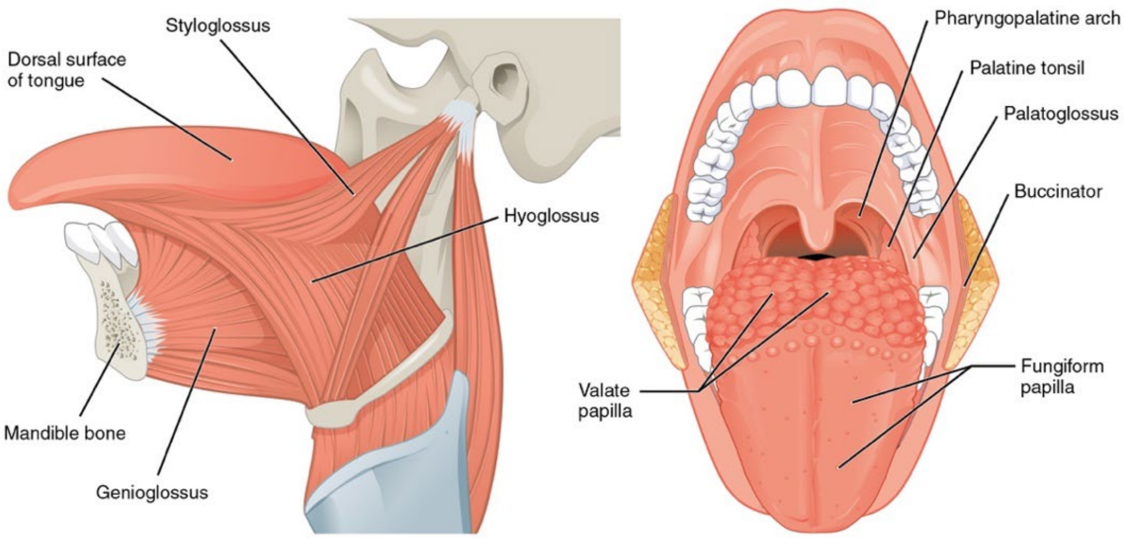


Figure 1. (a) Lateral view of the extrinsic tongue muscles (b) Frontal view of the tongue with the main anatomical structures highlighted

Image taken from Betts J, Young K, Wise J, Johnson E, Poe B, Kruse D et al. Axial Muscles of the Head, Neck, and Back. Opentextbc.ca. 2021

The tongue is further divided by the midline groove formed by a fibrous lingual septum into the right and left hemispheres.

The lingual frenulum is located on the inferior surface of the tongue connecting it to the floor of the mouth. **Figure 2.** It has been known that a hypertrophic or impaired frenulum has impacted tongue movement during mastication or phonation, due to the tongues inability to move freely. Ankyloglossia can also be produced by a short lingual frenulum, commonly referred to as tongue-tie (6).

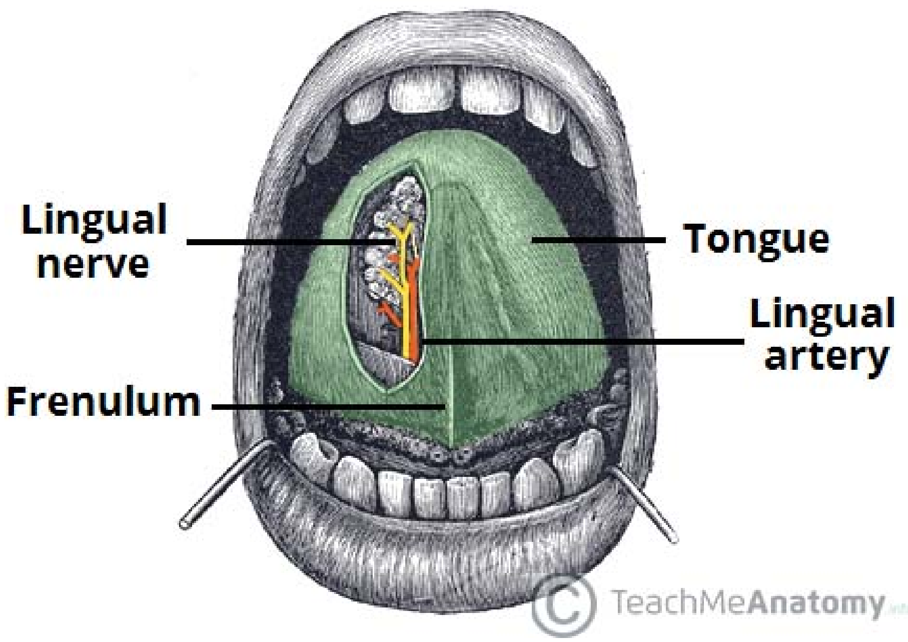


Figure 2. Frontal view with the tongue in an elevated position

Image taken from Kenning M. The Tongue. Teach Me Anatomy. 2019.

Musculature

Muscles of Mastication

Tongue-Jaw coordination is principally coordinated by the brain stem relying mainly on reflexive control to position correctly the tongue during mastication.

The four muscles of mastication appear in pairs, one on either side of the body; right and left. All four are innervated by the mandibular branch of the trigeminal nerve (cranial nerve V_3).

1. <u>Masseter</u>

The predominant mastication muscle being quadrangular in shape having a two-part structure: Deep and Superficial (7).

a. Origin:

Deep part- zygomatic arch of the temporal bone

Superficial part- maxillary process of the zygomatic bone

b. Insertion: angle/ramus of the mandible.

c. Action: prime <u>elevator</u> of the mandible causing jaw closure. Contraction of this muscle moves food back to the midline assisting the tongue to maintain food on top of the active cusps of posterior teeth for reducing.

d. Innervation: Mandibular Nerve V_3

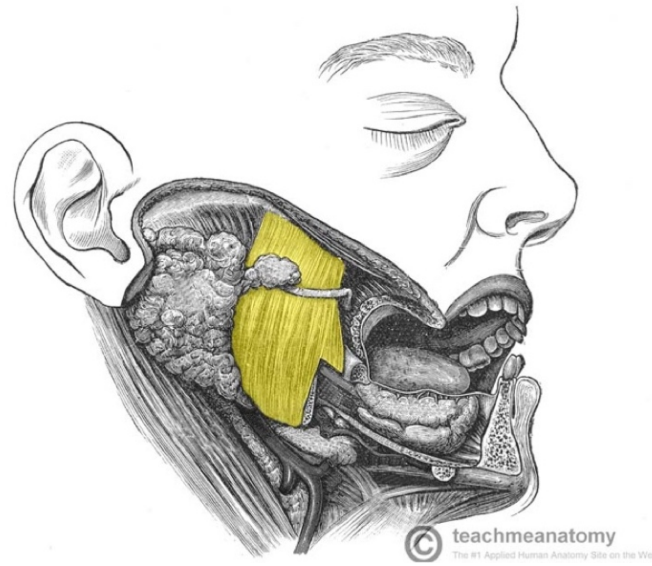


Figure 3. Lateral view of the Masseter highlighted in yellow

Image taken from Jones O. The Muscles of Mastication. Teach Me Anatomy. 2021

2. <u>Temporalis</u>

A fan-shaped muscle seated in the temporal fossa located on the lateral periphery of the cranium. It is enclosed by a durable fascia and condenses to form a tendon (8).

a. Origin: temporal fossa

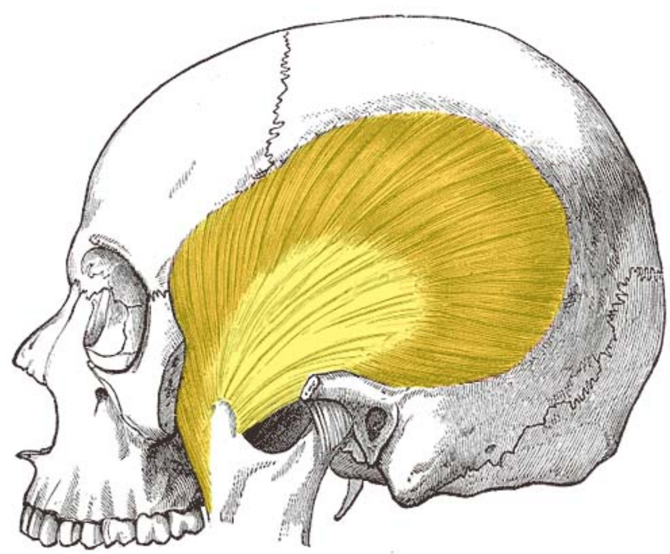


Figure 4. Lateral view of the Temporalis highlighted in yellow

Image taken from Jones O. The Muscles of Mastication. Teach Me Anatomy. 2021

b. Insertion: coronoid process of the mandible

c. Action: closure of the jaws, elevation and retraction of the mandible, enabling and maintaining the rest position.

d. Innervation: Mandibular Nerve V_3

3. Lateral Pterygoid

A triangular shaped, deep muscle that has both a superior and inferior head which eventually converges to yield a tendon (7).

a. Origin:

   Superior head- greater wing of the sphenoid bone

   Inferior head- lateral pterygoid plate of the sphenoid bone

b. Insertion: mandibular condyle and surrounding capsule of the temporomandibular joint.

c. Action: Prime mandibular protractor incited by horizontally orientated muscle fibres

   i. Bilateral action protrudes the mandible forward,

   ii. Unilateral action provides side to side grinding movements (7).

   Unilateral contraction of the lateral pterygoid will generate a movement on the contralateral side of the mandible meaning that a contraction of the right lateral pterygoid will deviate the mandible to the left.

d. Innervation: Mandibular Nerve V_3

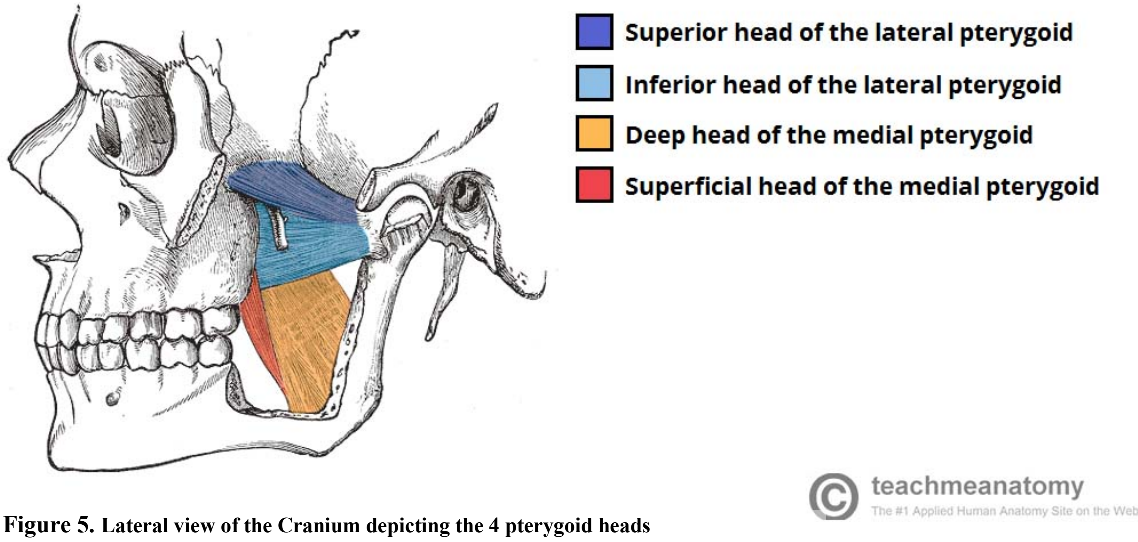


Figure 5. **Lateral view of the Cranium depicting the 4 pterygoid heads**

Image taken from Jones O. The Muscles of Mastication. Teach Me Anatomy. 2021

4. <u>Medial Pterygoid</u>

A quadrangular shaped muscle that has both a deep and superficial head situated inferiorly to the lateral pterygoid (7).

a. Origin:

   Superficial head- maxillary tuberosity and palatine process of the palatine bone

   Deep head- mesial surface of the lateral pterygoid plate of the sphenoid bone

b. Insertion: angle/ramus of the mandible on its mesial surface

c. Action: aids in elevation and <u>lateral movements</u>.

d. Innervation: Mandibular Nerve V_3

Although these muscles are vital for successful mastication, they are not specific to stimulate tongue movements during deglutition or mastication. Rather they enable the jaws to move during centric and eccentric movements.

With regards to the muscles that are used to specifically move the tongue, we find them categorised in two groups: intrinsic and extrinsic muscles (9).

Each group consists of 4 muscles, with each muscle having its own movement and function attached to it, depending on where it originates and terminates.

For example, the intrinsic group are specific to allow for more complex shape changes of the tongue, whereas extrinsic are for general position alterations.

Intrinsic Muscles of the Tongue

The very basis of tongue movements itself is endorsed through the anatomy of the skeletal muscles that form the bulk of the tongue. These intrinsic muscles, grouped in 4 muscular bands runs transversally from right to left, and longitudinally from posterior to anterior. **Figure 6.** They are entirely confined to the tongue, whereas extrinsic muscles are characterized by the extra glossal attachments from bone to tongue (10).

The tongue being composed of intrinsic muscle fibres in a unique way not seen anywhere else in the body, presents a peculiar ability to curl, squeeze and fold in on itself during phonation and mastication (11).

These intrinsic tongue muscles are arranged in several planes, producing the fine changes of shape with remarkable nimbleness and ease, characteristic of the tongue. However, they do not move the tongue itself, since they do not have any extra-glossal attachments outside of the tongue. Therefore, their action is to exclusively alter the shape of the tongue.

1. <u>SLM- Superior Longitudinal Muscle</u>

   Is located superior to the Transverse and Vertical intrinsic muscle

   a. Insertion: muscle fibres stretch from the fibrous median septum to the lateral tongue borders
   b. Action: Curling the apex and lateral borders upwards and when working with the Inferior Longitudinal muscle the tongue is shortened and retracted.
   c. Innervation: Hypoglossal nerve (CN XII)

2. <u>ILM- Inferior Longitudinal Muscle</u>

   Is located inferior to the Transverse and Vertical intrinsic muscle

   a. Insertion: from the tongue root to the apex.
   b. Action: Curling the apex and lateral borders downwards and when working with the Superior Longitudinal muscle to shorten and retract when it is protruding
   c. Innervation: Hypoglossal nerve (CN XII)

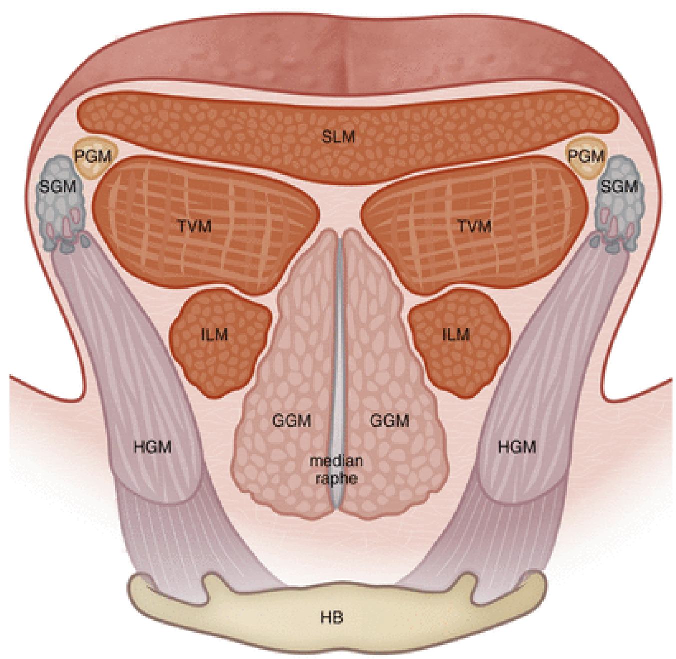


Figure 6. A cross-section of the tongue from a frontal view with the Intrinsic muscles highlighted

Image taken from Arx T, Lozanoff S. Tongue. Clinical Oral Anatomy. 2016;:489-506.

3. <u>TVM- Transverse Muscle</u>

   Is located between the Superior and Inferior intrinsic muscle

a. Insertion: muscle fibres extend from the fibrous median septum to the lateral margins of the tongue.
b. Action: elongation and protrusion of the tongue
c. Innervation: Hypoglossal nerve (CN XII)

4. VM- Vertical Muscle

Intersects with the Transverse muscle fibres, situating itself between the Superior and Inferior Longitudinal Muscles.

a. Insertion: muscle fibres extend from the dorsum of the tongue to the inferior surface of the tongue apex spreading to its lateral borders.
b. Action: Flatten and broaden the tongue
c. Innervation: Hypoglossal nerve (CN XII)

Extrinsic Muscles of the Tongue

The extrinsic muscles regulate the general, positional movements of the tongue as opposed to that of the finer, shape movements handled by the intrinsic muscles. **Figure 8.** This is due to the extra-glossal bone attachments resulting in movement of the tongue itself, not merely the shape. **Figure 7.** Four pairs of extrinsic muscles are found on either side of the tongue, each with the ability to protrude, retract, depress and elevate the tongue during mastication, phonation or deglutition (9).

1. Genioglossus

A fan-shaped muscle formulating the majority of the inferior tongue.

a. Origin: mental spine found on the internal surface of the mandibular bone, lateral to the symphysis.

b. Insertion: inferior tongue surface and the body of the hyoid bone.
c. Action: inhibition of posterior tongue retraction, avoiding an obstruction of respiration through protraction and depression of the tongue (12).
d. Innervation: Hypoglossal nerve (CN XII)

2. <u>Hyoglossus</u>

A thin, quadrangular shaped muscle found in the neck and floor of the mouth

a. Origin: The great cornu of the Hyoid bone
b. Insertion: into the lateral surfaces of the tongue
c. Action: Retraction and depression of the tongue body, apex and lateral borders inferiorly.
d. Innervation: Hypoglossal nerve (CN XII)

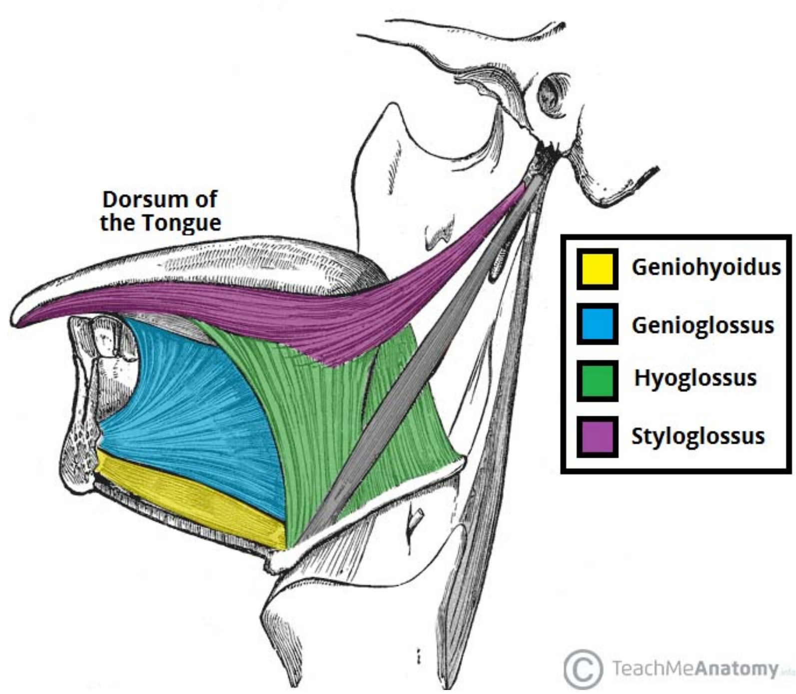


Figure 7. A lateral view of the Extrinsic Muscles of the tongue
Image taken from Kenning M. The Tongue. Teach Me Anatomy. 2019

3. <u>Styloglossus</u>

a. Origin: styloid process of the Temporal bone
b. Insertion: along the tongues lateral inferior surface merging with the Hyoglossus and Inferior Longitudinal Muscle
c. Action: retraction and elevation.
d. Innervation: Hypoglossal nerve (CN XII)

4. <u>Palatoglossus</u>

A paired muscle that forms the anterior pillars of the faucets, separating the oral cavity from the oropharynx.

a. Origin: inferior surface of the palatine aponeurosis

b. Insertion: posterolateral tongue.

c. Action: elevation of posterior tongue closer to the soft palate (9)

d. Innervation: Vagus nerve X and Glossopharyngeal nerve (CN IX)

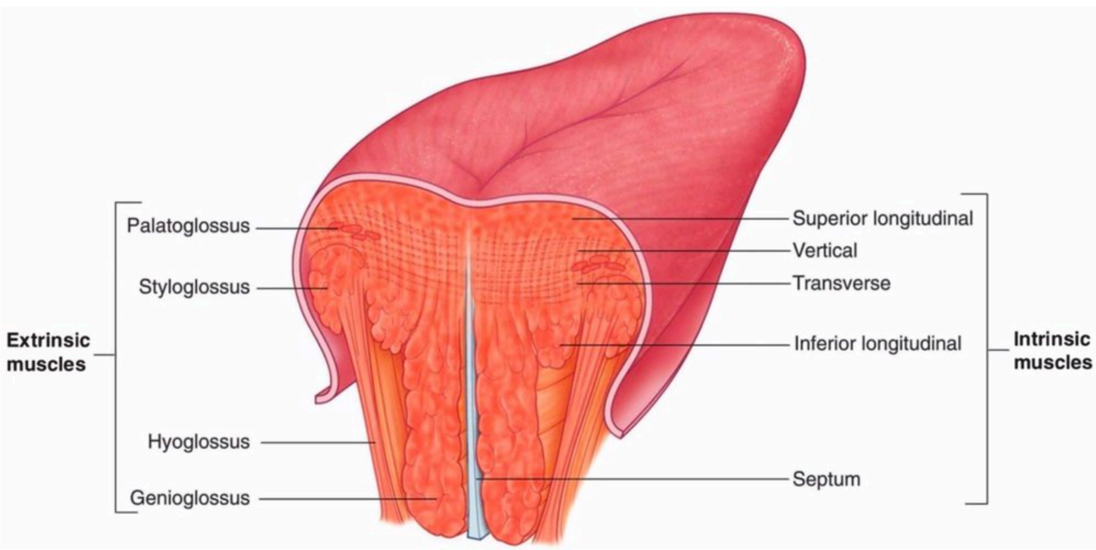


Figure 8. A cross-section of the tongue presenting the extrinsic and intrinsic muscles of the tongue, and the location of their fibres respectively

Image taken from Drake RL et al. Gray's Anatomy for Student.

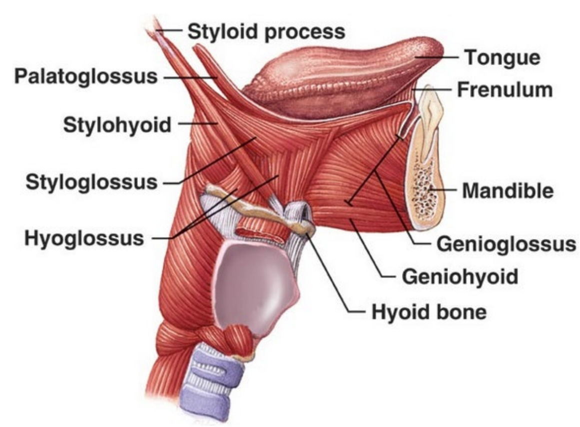


Figure 9. A lateral view of the tongue depicting the extrinsic muscles of the tongue

Image taken from Pandula V. Muscles responsible for Movements and Action of Tongue and their nerve supply. JuniorDentist.com (2021)

Innervation

With such a vast number of muscles, tissues and other anatomical structures present in the oral cavity, a dense vascularization with an extensive blood supply arising from the lingual artery, a branch of the external carotid artery as well as a rich innervation is needed to supply the locality (13). This innervation is categorized based upon its basic function of either a motor (physical) function or a sensory function. The sensory and motor functions of the tongue are all authorised by the cranial nerves (14), originating from various parts of the brain stem, consequently distinct nerve pairs will sanction diverse duties.

Motor

The muscles of the tongue are all innervated by the Hypoglossal nerve (CN XII), except for the Palatoglossus muscle which is instead supplied by the pharyngeal plexus comprised of both the Vagus nerve X and Glossopharyngeal nerve (CN IX) (14). These nerves provide the innervation needed to conduct the very physical movements of the tongue itself, during mastication and phonation, all orchestrated by the brain stem, inferring that they are reflexive movements.

Sensory

Now with regards to taste and the textures of foods themselves, sensory information is transmitted through an entirely distinct set of nerves, coined the sensory nerves.

- General and taste sensation from the posterior third of the tongue arises from the glossopharyngeal nerve (CN IX).
- Taste sensation for the anterior two-thirds of the tongue is coordinated through specialised sensory fibres of the chorda tympani, a branch of the facial nerve (CN VII).

- General sensation from the anterior two-thirds of the tongue is supplied by the lingual nerve, a branch of the mandibular nerve CN V3 (14).

Control of Tongue Movement

Tongue position in relation to the superior and inferior mandibles have been seen to be controlled by the hyoid bone, through the anterior and posterior suprahyoid muscles (15). The shape of the tongue is regulated by the extrinsic muscles functioning in harmony with the intrinsic muscles. Recent articles have described intrinsic muscles to be in a multi layered system of tightly packed layers of transverse, longitudinal, and vertical muscle fibres (16). These new anatomical discoveries are restructuring the original functional models of the tongue, to a now more sophisticated model. This in turn begins to explain the jaw-hyoid-tongue complex, or what's been coined the hyomandibular kinetic chain, vital in feeding and phonation, but whose observed behaviour was previously unexplained (17, 18). Through advancements in technology, many new imaging techniques have been developed, which can and have enabled examination of tongue movements during mastication and phonation. Certain literature has even stated that these imaging techniques have shown localised tongue change during mastication, and an extensive shape change during phonation. It is evident that many of the actions implemented by the tongue in phonation, are also seen during mastication. Thus, giving rise to the suggestion that the range of shapes used in feeding is the basis for both activities (19).

Tongue Movement

Abd-el- Malek was the first to describe tongue movements in 1955 after studying its anatomy in detail in 1939. He solely used eye observation and still cameras to record the principal tongue profiles employed during mastication, highlighting the tongue´s unique ability to protrude, retrude, twist and went so far as to suggest the possible intrinsic shape changes (17).

Using still photographic images taken from a patient, El-Malek illustrated how the tongue arches to form a depression for the placement of food onto the tongue during feeding. **Figure 10**. The hollowing of the anterior surface to the altitude of the occlusal plane, and the arching of the posterior tongue stimulates hyoid bone movement. Which in turn, depresses and retracts the tongue, resulting in the food being carried backward, which later became known as Stage 1 transport.

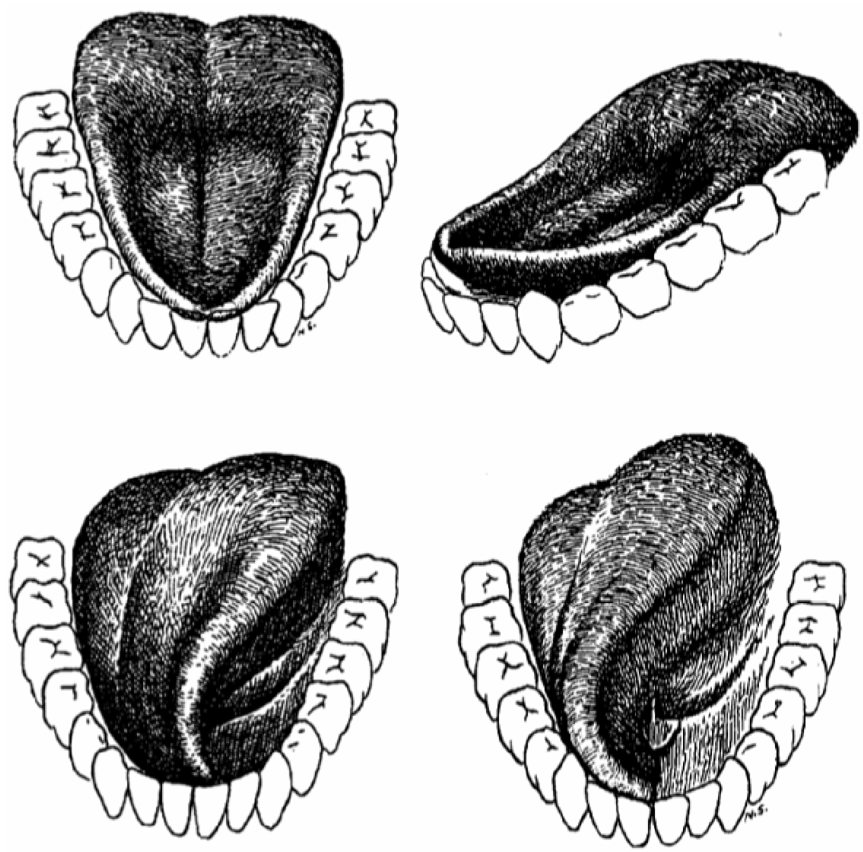


Figure 10. Changes in tongue shape during feeding as presented in the drawings of Abd-el-Malek
Image taken from Hiiemae K, Palmer J. Tongue Movements in Feeding and Speech. Critical Reviews in Oral Biology & Medicine. 2003;14(6):413-429.

He then went on to outline the twisting movement as it revolves around the tongue’s long axis, enabling the placement and maintenance of food onto the active cusps of the posterior teeth during Stage 1 processing.

Two important features of tongue movement are seen during mastication:

- lateral borders of the tongue can move independently of the body

- anterior and middle third can move independently to produce an anterior cavity specific for food placement, along with arching of the posterior third of tongue

Abd-el-Malek was unable to measure dimensional changes within the tongue itself nor how it changes from one position to another. Further developments in technology allowed for the expansion and contraction of the tongue to be measured, primarily through the level of change of tongue markers placed upon the teeth (17).

Methods of Observing Tongue Movements

Since the time of El-Malek there has been various advancements in technology that have enabled us to better our understanding of the movements that the tongue executes whilst undertaking the masticatory process. Namely 6 methods have been developed:

1. **ELECTROPALATOGRAPHY (EPG)**

uses intra-oral sensors attached to a thin plastic 'base-plate' positioned on the hard palate. It is limited since the movement of the tongue is not measured, merely the tongue-palate contacts. It successfully measures tongue movement during liquid or semi-liquid (yogurt, jelly) ingestion, however, failed on solid foods.

2. **ELECTROMAGNETIC ARTICULOMETER (EMA)**

uses transmitter coils for monitoring movements during phonation. However, it is limited by the size of coils, as they detach during mastication reducing the accuracy of the recorded results. It is useful as it records jaw movement in 3D but cannot be reliably used for the tongue.

3. APPLIED DIAGNOSTIC CINERADIOGRAPHY (CFG) AND VIDEOFLUOROGRAPHY (VFG)

Uses clinical cameras and frames of film with radiation detected by a CFG diagnostic machine. This method was used for the earliest studies of human swallowing and later provided the basis for a series of studies in which the complete mastication process, including the role of the tongue in food transport, was illustrated. Although limited by the recording of 3D events, in 2D images, the studies performed by Hiiemae and Palmer, 1999 became the foundation for the Process Model of Feeding in humans (17).

4. X-RAY MICROBEAM (XRMB)

Again, uses cameras and film but this time using a lower level of radiation when compared to that of VFG. However, it is limited as it captures the position of gold pellets glued to the teeth, not the movements of the tongue itself.

5. ULTRASONOGRAPHY (US)

A highly advanced technique that captures images of soft tissues in real time without ionizing radiation and can generate a 3D model of the tongue. It's been noted that the presence of air under the anterior and lateral borders of the tongue can prevent imaging. Furthermore, during deglutition, posterior tongue action is faster than the frame rate we have available today, thus its mainly used in phonation studies.

6. **MAGNETIC RESONANCE IMAGING (MRI)**

Examines soft tissues mainly for diagnostic purposes and as a research tool for speech and deglutition.

VFG is the gold standard for the study of orofacial and pharyngeal activities in mastication with US and MRI being used for complementary, research purposes (17).

OBJECTIVES

This project was written with the objective of

1. describing how the nature of the tongue's movement influences the mastication process, thus in turn bolus distribution and deglutition alike.
2. observing how the tongue would be affected upon the apparition of a lesion to the lingual nerve.

MATERIALS AND METHODS

Research for this dissertation was sourced through medical search engines such as google scholar, Pubmed and NCBI. Filters were applied to narrow the search and eliminate the articles that did not contain the information related to the objectives. A set of relevant articles was initially sourced, for further reading, then referenced in the bibliography in Vancouver style. Further articles were then hand selected and ensuring that no article older than 20 years was used, except for references to scientific observational experiments that were conducted prior to the millennial. This was done to guarantee the validity and accuracy of the information provided, ensuring it’s the most up to date possible. The bibliography was compiled through employing a strict exclusion criterion of articles thus enforcing the elimination of bias, misinformation or information unrelated to the topic. The key words searched for the assembly of this project were “Tongue”, “movements”, “mastication”, “lesion” and “lingual nerve”.

The basis of oral anatomy and the anatomical landmarks for this project was provided by a 3-Dimentional atlas funded by The Visible Human Project, that began as an initiative in 1986 by the National Library of Medicine (NLM) and still continues today (10). Through their ongoing payments to researchers and medical scientists, a database of human anatomy gradually grew into an extensive library containing comprehensive information on materials such as tongue anatomy, masticatory muscles and muscles of the tongue. The action of each muscle, its origin, insertion and innervation were all described to provide information on how mastication is instigated and functions symbiotically with tongue movements to achieve the most efficient food processing. The same was completed for the extrinsic and intrinsic muscles of the tongue, with the movements of each muscle and the corresponding innervation highlighted, as they are specific to stimulating tongue movements exclusively. An observation of the general innervation present in the oral cavity was made, and then discussed more specifically the ones used to innervate the tongue, to methodically classify them under either a motor or sensory function.

Recent articles from 2010 were included explaining the kinetic chain which correlates the tongue to the movement of both the mandibles and that of the hyoid bone, something that was previously unknown. An experiment conducted by the NLM included a lateral VFG recording of 16 healthy patients consuming solid foods in both the lateral and vertical sense. The results from this study showed a high vertical correlation (R=0.87) between the tongue and the hyomandibular complex during mastication and a moderate horizontal correlation of (R=0.47).

This study suggested the jaw-hyoid-tongue complex, kinetic chain, which is now regarded as vital for tongue movement during mastication and phonation (18).

Although the majority of the articles sourced in this project was no older than 20 years, the drawings Abd-El-Malek produced in 1955 in his research paper “The part played by the tongue in mastication and deglutition”, were also included as a tribute to him. His article and method of observation was so accurate that it has been the foundation for a broad range of anatomical research in this field still used till today. Most notably Hiiemae and Palmer (17) were seen to be the ones to take this research further, using advancements in technology through CFG/VFG, to observe tongue movements laying the foundation for the Process Model of Feeding in humans, summarizing them into 4 sequential stages. They did this by conducting an experiment on 5 individuals, instructing them to consume chicken or cookies at allocated times, with a VFG recording system activated, to observe the movements of the tongue. They observed a chronological sequence in 70% of the 224 cycles recorded, hence confirming a relationship between tongue and jaw movements during mastication. They were able to record the individual movements the tongue undergoes and subsequently classified them accordingly (20). Variations in such movements were also studied by Dodds with an experiment being conducted through subjects being instructed to hold a bolus of thin Barium in the mouth and swallow on command. Using VFG technology it became apparent that there are two main types of normal oral swallow named 'tipper' and 'dipper' swallow. The majority of subjects were 'tipper' meaning they would form a bolus between the superior surface of the tongue and the palate, curving the apex of the tongue upward, positioning it on the lingual surface of Maxillary incisors and the alveolar ridge. However, some were seen to hold the liquid between the inferior surface of the tongue and the floor of the mouth and with the apex of the tongue pointing downward originally. It was then noted that the execution of an extra scooping motion to elevate the bolus supragingivally was needed, prior to proceeding as a 'tipper' type swallow (21).

The Nation Library of Medicine served as the basis for the fundamentals of lingual nerve anatomy, physiology and its following trajectory. It led to the Sunderland classification of the effects of lingual nerve injury in 1951, due to it being a frequent injury which Dr. AlAli quoted to be occasionally inevitable due to the procedure performed or the anatomy of the lingual nerve itself. Although caused by a multiplicity of aetiologies, the follow up study performed by Renton suggested that the principal aetiology was needle injury from anaesthesia and also the extraction of posterior molars (22). He methodically conducted a 4-year prospective study, of 2134 molar operations in 1384 consecutive days, and found lingual injury to range from 0.3-1%. Independent risk factors were deemed the main predictors for lingual nerve injury, thus if made aware of them it enabled the professional to avoid whist performing surgery. His work provided us with the materials necessary for the compilation of the recommendations to avoid lingual nerve injury as well as the rehabilitation protocol post trauma. Special surgical considerations were included in this thesis to heighten the readers awareness whilst performing surgical procedures on a patient.

RESULTS AND DISCUSSION

There is a distinct difference between positional change of the tongue in space, and localised shape change of the tongue itself, irrespective of its position. During mastication, the position and shape of the tongue changes in relation to jaw movement. However, during phonation, changes in tongue shape occurs with minimal jaw movement. Consequently, less change in the overall spatial position of the tongue is seen during phonation, suggesting a greater independence (17).

The Process Model of Feeding, Hiiemae and Palmer (17), seen through CFG/VFG, which we saw earlier being labelled as the gold standard for tongue movement observation, describes four chronological phases when outlining tongue movements during mastication. Commencing with Stage 1A Initial Transport, whereby consumed food is transported from the anterior incisal region to the posterior molar region for Stage 1B Processing, reducing food to morsel size. Following this is the Stage 2A Final Transport whereby the reduced morsels are transported through the fauces to form the bolus thus enabling to pass to the final Stage 2B Bolus Formation and subsequent Deglutition.

STAGE 1A: INITIAL TRANSPORT

Upon opening of the mandibles, the anterior-middle tongue surface is hollowed with the posterior tongue arched to form a cradle ready to receive the morsel of food, to be deposited onto the tongue. **Figure 11.** The tongue is then depressed to the altitude of the occlusal plane with the hyoid bone and tongue being abruptly retruded and depressed. This hyoid movement results in closure of the oropharynx in the lateral sense and the retrograde transport of food

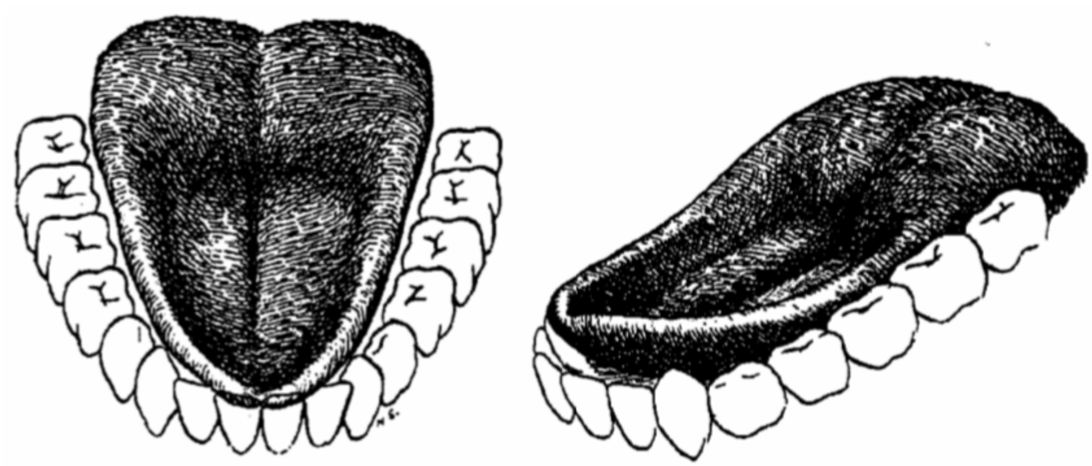


Figure 11. The hollowing of the tongue forming the cradle ready to receive flood
Image taken from Hiiemae K, Palmer J. Tongue Movements in Feeding and Speech. Critical Reviews in Oral Biology & Medicine. 2003;14(6):413-429.

on the retracting tongue. As the mandibles begin to close, the tongue starts to rise pulling the bite posteriorly to the level of the molars and elevating it forward and upward, bringing it closer to the antagonistic molars. There is a smaller open-close movement just prior to intercuspation, through a twisting tongue movement that places and maintains food onto the occlusal surface of the posterior teeth during this Stage. **Figure 12.** The retraction of the tongue-hyoid-jaw complex is referred to as the 'pull-back'. The tongue performs these movements in every chewing cycle during mastication in an attempt to move ingested food from the incisal area to the premolars and molars for processing.

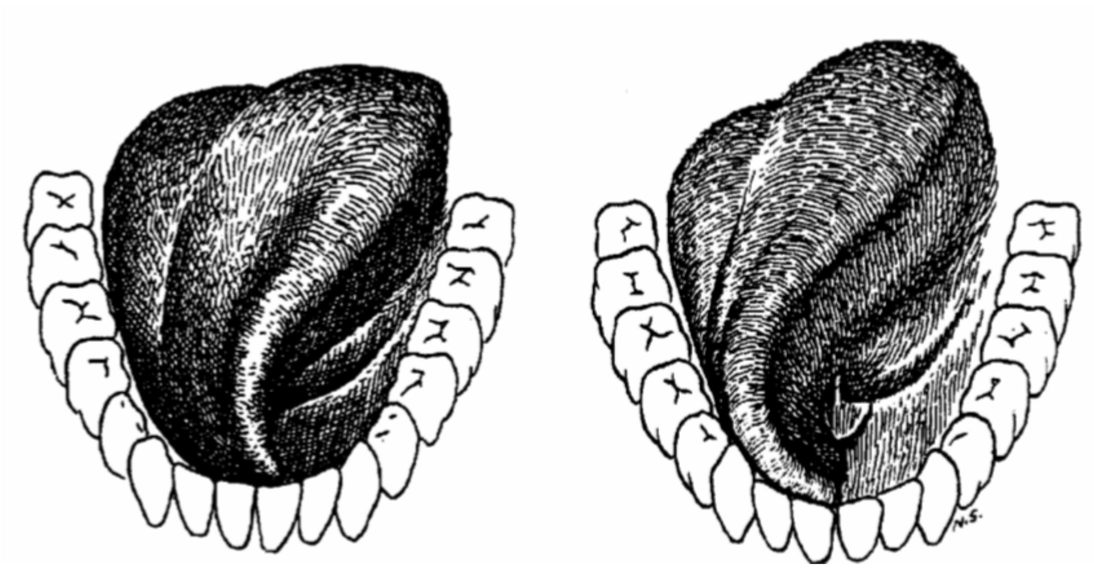


Figure 12. The twisting movement of the tongue allowing placement onto the occlusal table

Image taken from Hiiemae K, Palmer J. Tongue Movements in Feeding and Speech. Critical Reviews in Oral Biology & Medicine. 2003;14(6):413-429.

STAGE 1B: PROCESSING

This is the stage where the ingested food is continuously reduced forming smaller morsels, with intricate tongue movements being seen in both sagittal and coronal planes, commonly known as Cycles. **Figure 13A.** During the masticatory process there is a maximal opening and a maximal intercuspation where the jaws are closed, with varying tongue and jaw movements involved with each stage.

In the sagittal plane during maximal opening the jaws drop, and the tongue moves into a downward position, and once the jaws begin to close, the tongue assumes an upward and backward position as the mandible moves up closing the cycle. Once in intercuspation the tongue is seen in its most posterior position, as well as elevated to its most palatal position, just behind the upper incisors. Occasionally a delay can be observed during palatal tongue elevation, which has been suggested to arise from congenital tongue biting during mastication (17).

As the jaws begin to open again for maximal opening, the tip of the tongue cycles forward then downward pressing the tongue body close to the palate, ending in deglutition if the food has been adequately processed. If not, then it is once again reprocessed and transported to the posterior teeth. These cycles generally move reduced food anteriorly, so the tongue tip is known to elevate and collect food from the anterior hard palate as the jaws begin to separate. And using the 'pull back mechanism', the tongue returns the bolus to the molars through a retrusive movement as the mandible reaches maximal opening. In the coronal plane, the togue rotates around its axis to turn its gustatory surface toward either one or the other side of posterior teeth for taste purposes. As processing continues, the tongue maintains inadequately grinded food on top of the teeth cusps.

It was recently shown by Mioche et al. (17), that an interactive relationship between the tongue and cheeks is present, even though it had not been documented until recently. This relationship was established due to various advancements in the VFG methods of observing tongue movements as previously stated. Mioche demonstrated that as the tongue compresses food horizontally to conserve it on the occlusal surface, it also pushed upon the mucosa of the cheek in some cases.

Following 3 complete tongue-jaw cycles, the buccinator contracts, moving food back to the midline. Food is then transferred across the midline by a reverse longitudinal rotation of the tongue during maximal opening. Once the rate of mastication decreases and presents an irregular pattern, the tongue twists and turns to dislodge any remaining pieces of food held in the vestibules of the cheeks and the floor of the mouth. This is known as the period of clearance.

STAGE 2A: FINAL TRANSPORT

The transport of matter through the pillars of the faucets demarks the start of the liquid swallow and the establishment of bolus formation in the oropharynx (23). The apex and tongue body rise, coming into contact with the anterior hard palate, progressively spreading posteriorly pushing the food to the back of the pharynx. **Figure 13B.** This mechanism has been coined squeeze back by Hiiemae and Crompton (23). It is important to note that the tongue itself does not move posteriorly, rather it ascends in a sequential manner thrusting the food backwardly during the early opening phase of the jaw movement cycle.

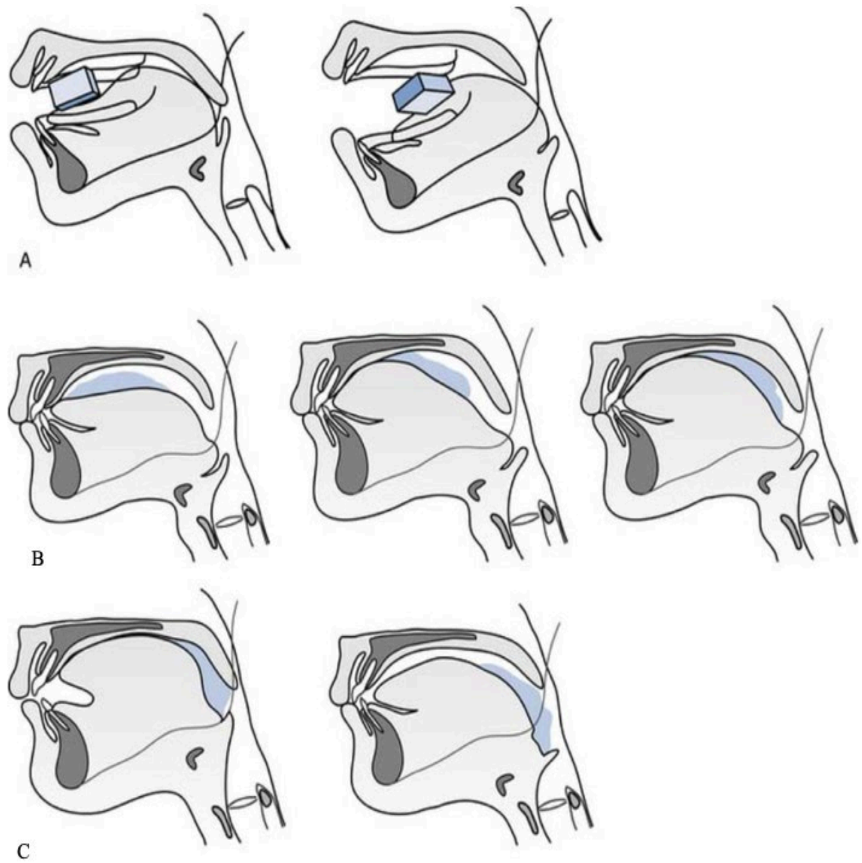


Figure 13. Lateral view of a solid bolus transport and swallow based on actual VFG sequence recording. 13A- Stage 1 Initial Transport followed by Stage 1 Processing 13B- Stage 2 Final Transport depicting the tongue touching three position of the palate 13C-Stage 2 Bolus Formation and propulsion through the fauces

Image taken from Palmer J, Pelletier C, Matsuo K. Rehabilitation of Patients with Swallowing Disorders. Musculoskeletal Key. 2021 [cited 13 April 2021

STAGE 2B: BOLUS FORMATION AND DEGLUTITON

Once ready to swallow, the tongue forms an anterolateral seal around the bolus and a posterior seal between the tongue and palate at the junction of the hard and soft palates, inhibiting any premature movement of liquid into the pharynx. Upon swallowing, the anterior tongue-palate connection develops even further posteriorly, squeezing the bolus to the rearmost of the pharynx. Deglutition originally follows the same mechanism as the 'squeeze back' previously seen in Stage 2 Final Transport, but this time a progression of it due to the posterior part of the tongue descending and eliminating the posterior oral seal. Due to its elimination, the bolus is permitted to pass into the pharynx, initiating the deglutition sequence and closing both the larynx folds and pharyngeal isthmus. **Figure 13C.**

Bolus propulsion is caused by the pharyngeal surface of the tongue pushing posteriorly, now referred to as 'tongue base retraction', making contact with the contracted pharyngeal wall thus pushing the bolus through the pharynx and the upper oesophageal sphincter.

Variations in bolus formation and deglutition

Dodds et al. (24) studied behaviour regarding the swallowing of liquids and noticed variations between subjects. Essentially subjects were instructed to hold a bolus of liquid in the mouth and swallow on command. The majority of subjects would form a bolus between the superior surface of the tongue and the palate, curving the apex of the tongue upward and arching the posterior tongue to form the hollowed depression. However, some were seen to hold the liquid between the inferior surface of the tongue and the floor of the mouth and point the apex of the tongue downward. They were subsequently named 'tipper' and 'dipper' swallow types respectively.

Another variation was seen during bolus accumulation in the pharynx, with multiple cycles lasting up to about 10 or 12 sec in healthy individuals. In contrast, these times greatly increased for unwell or muscle deficient or spasmodic patients (17).

Effects of a Lingual Nerve Lesion

The results of lingual nerve damage are predicted according to the anatomy and physiology of the nerve trajectory, which in turn affects the function. Highlighting the anatomy of the LN in light of common risks, resulting in the effects lesions will have on tongue movements. Furthermore, potential treatment options currently in use, and their efficacy in the restoration of function, following an injury.

The Lingual nerve finds its origin at the Spix spine, following the trifurcation of the mandibular branch V3 of the trigeminal nerve to form, 3 troncular nerves; inferior alveolar (IAN), long buccal (LB) and lingual nerve (LN) (25). The Lingual Nerve travels medial to the IAN (26) running downward and forward, deep to the mandibular ramus as seen in **Figure 14.**

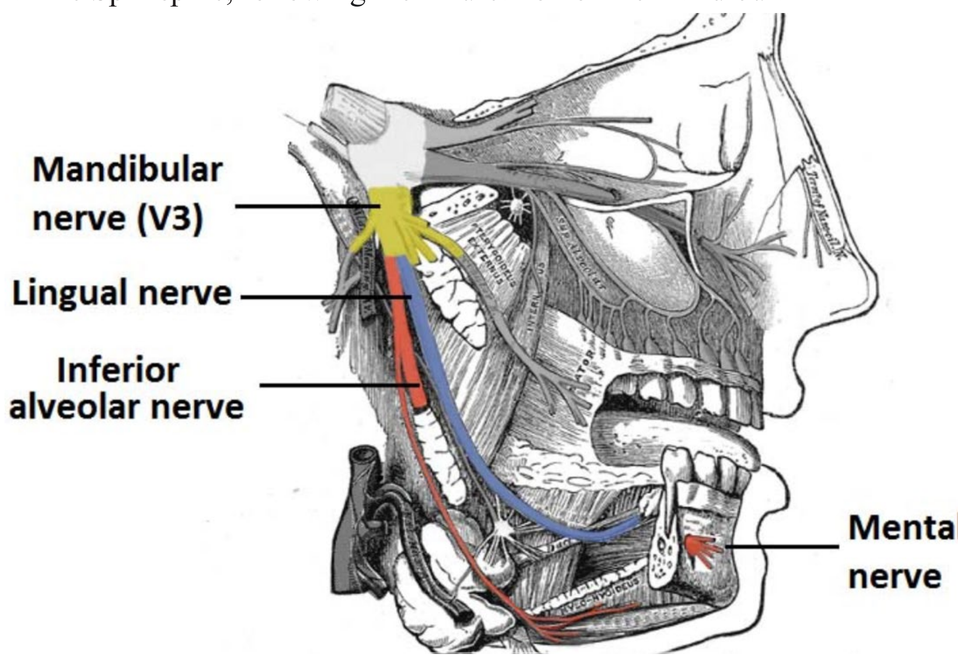


Figure 14. **Lateral diagram of the partition of the V3 into the IAN and LN, terminating in the mental foramen as the Mental nerve**

Image taken from Little S. The Mandibular Division of the Trigeminal Nerve (CNV3) [Internet]. Teach me anatomy. 2021

This lingual partition of the V3 is accountable for general sensory innervation as it innervates the mucous membranes of the mandibular lingual gingiva, floor of the mouth and the anterior two-thirds of the tongue (27). It is interesting to note that the LN not only carries fibres that are part of the trigeminal V3, but additionally specialized taste fibres called the Chorda Tympani (CT), that branch from the cranial nerve VII (facial nerve) with autonomic fibers relaying to the submandibular ganglion (28). **Figure 15.**

Although the LN is seldom encountered during maxillofacial surgery it is repeatedly seen in daily dental practice through procedures such as IAN troncular blocks, thus an immaculate understanding of its anatomy and proneness to iatrogenic injury due to its susceptible position is advised (28). Patients who have sustained a unilateral LN injury, often instigated through standard oral procedures such as tooth extractions, anaesthesia, and osteotomies, collectively complain of impairment in eating, drinking, swallow control, and even an altered phonatory performance (29, 30). Through rigorous article research, it was seen that injury to the LN and the effects that follow as a consequence, varied based on the type of procedure that was performed, leading to the injury (31).

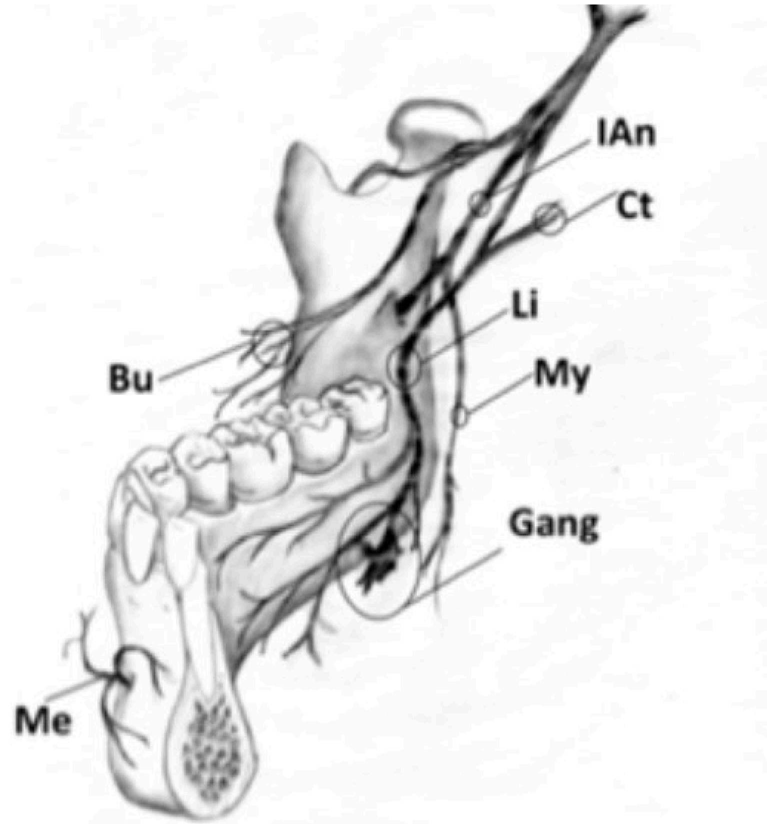


Figure 15. Frontal view of the nerve trajectory on a right, inferior hemi arch. Take note as to how the Chorda Tympani joins the Lingual Nerve posteriorly. IAN: Inferior alveolar nerve; Ct: Chorda tympani; Lingual nerve (Li); Mylohyoid Nerve (My); Long Buccal nerve (Bu); Submandibular Ganglion (Gang); Mental nerve (Me)

Image taken from Alali Y, Mangat H, Caminiti M. Lingual Nerve Injury: Surgical Anatomy and Management. Oral Health Group. 2021

It was even put forth by Dr. Alali that LN injury is sometimes inevitable, when certain procedures such as head and neck cancer removal is performed (28). Nevertheless, it became disturbingly apparent that the majority of LN injuries originated from non-cancerous procedures, most notably an iatrogenic basis. The incidence of LN injury during extractions of mandibular third molar were reported to range between 0.6% to 2.0% (22). Fortunately, permanent harm to the LN from third molar surgery appears far less frequently, ranging from 0.04% to 0.6% (32). Whereas the incidence of LN injury after carrying out a sagittal split ramus osteotomy was seen to range from 9% to 19.4% (32). This postulates that orthognathic and maxillofacial surgery is the leading cause for LN injury, due to such high incidence rate. It was cited by Jerjes that the increased age of patients, degree of complexity of the mandibular third molar impaction and the level of surgeon expertise have all been shown to determine the potential risk of permanent LN injury (33). The frequency of LN and IAN injuries caused by local anaesthetic block injections ranged between 1:26,762 to 1:800,000 (34). However, according to Renton the aetiology of LN injury principally stems from physical damage arising due to a needle related incident causing significant haemorrhage, inflammation and scarring culminating in demyelination of the nerve itself (34). This is perhaps due to routine dental treatment having the potential to damage the lingual nerve as it is more frequently performed, than that of maxillofacial surgery.

Results of Lingual Nerve Damage

Articles produced by Kim S.Y. (35) have illustrated that the Lingual Nerve is vulnerable to injury through a multiplicity of procedures including the application of local anaesthesia, third molar extraction, pre-prosthetic surgery as well as orthognathic surgery. As demonstrated below in **Figure 16.**

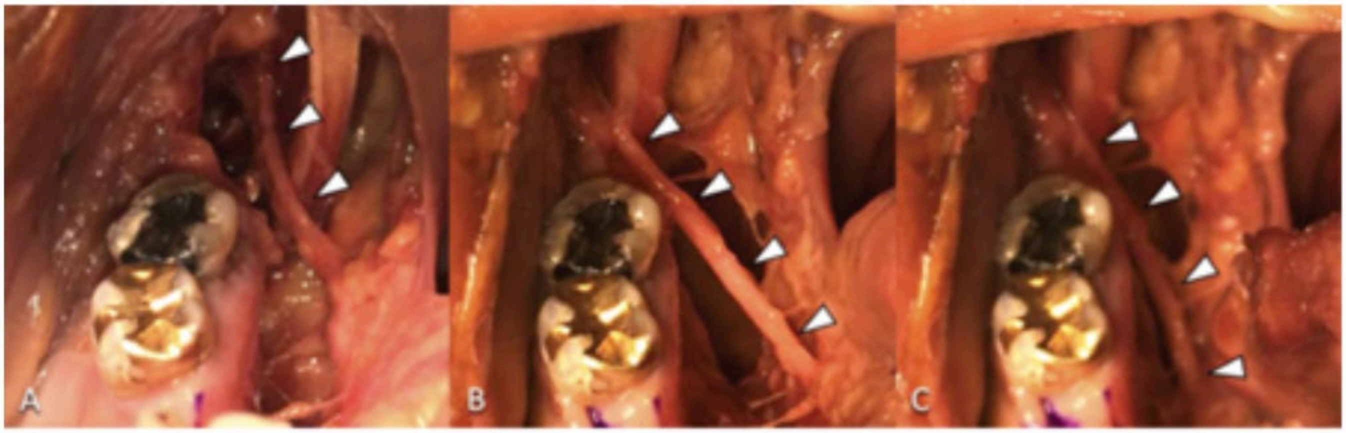


Figure 16. LN position shown with White arrows, changes location upon various tongue movements, during a superior pharyngeal constrictor muscle removal in orthognathic surgery. A: Neutral position. B: Protruding, left deviation and elevated position C: Lower position tooth 47

Image taken from J. Iwanga Clinical Anatomy 30:467–469 (2017), The Clinical View for Dissection of the Lingual Nerve with Application to Minimizing Iatrogenic Injury

The aetiologies of lingual nerve lesions have been further summarized in **Table 1.**

Table 1 Aetiology of Lingual Nerve injury

Administration of local anaesthetic
Removal of mandibular third molars
Surgical insertion of dental implants
Iatrogenic instrumentation during mandibular osteotomies
Primary soft tissue closure via sutures
Flap manipulation and management
Floor of mouth soft tissue manipulation
Blunt instrumentation (elevators, periosteal elevators)
Crush injuries (rongeurs, haemostats)
Surgical instruments (scalpel blade, drills, needles)
Stretch injuries (inappropriate tension or tearing of lingual mucosa)
Chemical injuries (local anaesthetic, haemostatic, endodontic materials)
Heat (cautery, laser, rotary burns)

It is fundamental to bear in mind the complex sensory nature of the LN because even the slightest lesion can result in irrevocable damage such as altered salivary secretion on affected side, loss of taste (specialised sensory) of the anterior two-thirds of the tongue, temporary or permanent general sensory alterations to the anterior two-thirds of the tongue and floor of mouth (36).

Oral symptomatology may present itself through anaesthesia, paraesthesia, dysesthesia or hypoesthesia, observing a loss of sensory function producing changes in notable speech patterns, pain, burning sensation, drooling, and tongue biting (37). These injuries have been summarized below in **Table 2.**

Table 2 Results of Lingual Nerve injury

Alteration In:	**Sign / Symptom**
Sensation	Burning Pain, Tingling
Position (proprioception)	Biting Tongue
Taste	Taste Alteration
Salivation	Decreased production/ drooling
Phonation	Slurring/ impaired speech

Classification of Lingual Nerve Damage

The effect of a lesion upon the lingual nerve has been seen to vary such that in 1951 Sunderland classified nerve impairment based on the degree of tissue damage (38).

Type 1- First degree injury - Neuropraxia

Referred to as Neuropraxia due to nerve trunk manipulation arising from a mild traction or compression force. This type of injury usually spontaneously recovers after a few weeks or months. This transient ischaemia is temporary with potential to become permanent if ischemia is maintained for a prolonged period.

Type 2- Second degree injury- Axonotmesis

Referred to as axonotmesis due to prominent traction or compressive forces disturbing certain axons. This in turn causes localised oedema which decreases blood flow in said area, thus resulting in conduction block. Variable recovery noted in patients with spontaneous recovery in several months.

Type 3- Third degree injury- Mild Neurotmesis

Severe nerve traction or compression causing localised myelin damage resulting in scar tissue replacing existing tissues, partially blocking neuronal regeneration. This in turn delays recovery limiting spontaneous recovery inferring permanent loss of sensation in certain areas. Surgical reconstruction is indicated.

Type 4- Forth degree injury- Fascicular disruption - Medium Neurotmesis

All components damaged except the epineurium, with scar tissue replacing existing tissues completely blocking neuronal regeneration. No recovery without surgical reconstruction.

Type 5- Fifth degree injury- Nerve transection – Severe Neurotmesis

Referred to as nerve transection due to all components including the epineurium being damaged. No recovery without surgical reconstruction.

It has been noted that if a patient describes a complete numbness which gradually decreases with time then it is more indicative of either the 1st or 2nd type (38).

Effects of LN Injury

Individual differences in the population may lead to either a full mouth affectation, or individuals completely unaffected, with genetics or variations in nerve trajectory being the deciding factor. It has even been reported an occasional hypersensitivity that may develop if the lesion was produced early in life, most notably an elevation in sweet and fat palatability (2). Localized damage to nerves can augment sensation in other regions of the mouth due to central interactions between nerves resulting in an over compensatory mechanism and an altered state of taste. **Subject Z of Annex 1 (Figure A.3).** This has produced long term alterations in diet due to subjects perceiving certain food textures and tastes unattractive, even if they originally use to enjoy said foods. Even more disturbingly, the inclusion of an unpleasant phantom sensation that appears to lack a clear origin has been described (2). **Subject Y of Annex 1 (Figure A.2).** However, its presentation has been seen to vary in patients as either a tingling pain along the nerve trajectory or burning mouth syndrome or atrophy of lingual papillae on a hemi lateral side, as seen in **Subject X of Annex 1 (Figure A.1).**

Limitations of the Study

Conceptional knowledge of the names of spatial positions occupied by the tongue, relevant to anatomy, innervation and musculature was used in this article with the assumption that the reader has prior knowledge of anatomy, as well as a strong foundation in medical terminology.

The case studies of observed lesions to the lingual nerve have generally been patients from a similar age group. However, it has been seen that younger age groups are more likely to heal, at a faster pace when compared to that of the older generation. This case study did not take into consideration how age modifies the effect of lingual nerve lesion.

It is well known amongst dentists that when the lingual nerve is anesthetized, it is usually alongside an IAN troncular block for mandibular treatments. Therefore, it would have been a broader, more complete research had lesions on the IAN and the effects that follow, been included. This suggests that this project was exclusively limited to the effects of lingual nerve damage, without taking into account adjacent nerves such IAN, V3, chorda tympani etc. As we have seen a multiplicity of nerves innervating the tongue, it would be an interesting study to follow up the various effects of lesions on these nerves, with their corresponding differences highlighted.

Direction of Possible Future Works

This project focused solely on the tongue movements during mastication and did not delve to that of an extent, the importance of the tongue for phonation nor the relative movements. Perhaps the observation of the lingual position in relation to the teeth, would have been interesting, as there is a diversity of tongue movements employed during the phonation of certain letters and words. This would have demonstrated how the effects of a lesion to the lingual nerve affect phonation, in turn reducing the clarity of certain words, augmenting talking difficulty due to a decrease in proprioception. A decisive comparison could then be made between the noticeability of a lingual nerve lesion during phonation and mastication. Furthermore, it's possible that different language may notice less the effects of such a lesion during phonation, so a few examples displaying this would have made this project a more diverse and unique study.

Finally, this project was limited by the age of the subjects that tongue movements and lingual nerve lesions were observed. The movements and recovery rate of children have been known to vary from their adult counterpart, thus the differences between these tongue movements during mastication would have made for an interesting comparison. The origins of lingual movements and the mandibles alike, during phonation has been suggested to have evolved from movements seen in infantile babbling. This idea has its supporters and critics, but has not been proven, and as far as we know, no one has yet attempted to test it experimentally. Our projects objectives did not include these concepts; thus, it was consequently left out of this study. Perhaps a future dissertation could cover it, as it is a reasonable hypothesis that the essence of tongue movements during mastication and phonation were derived from the wide variety of tongue movements seen in suckling, feeding and babbling as an infant.

CONCLUSION

1. A broad range of lingual movements are employed to transport food and maintain it on the occlusal surface for processing, and subsequently to form the bolus in the feeding process. It was made possible to observe them using VFG cameras, thus a Process Model of Feeding was produced, describing the mastication process and the tongue movements employed.
2. The effects of a lingual nerve lesion on the tongue movements itself, were seen to fluctuate greatly between patients due to differences based upon the mechanism of injury, the aetiology, the duration of the nerve injury and the patient's symptoms. They mainly arose due to poor planning, surgical technique and inadequate handling of LN injury postoperatively. Thus, we as medical professionals must be aware of the difficulty to rehabilitate nerves, irrespective of advancements in micro neurosurgical intervention, and acknowledge that the best method to avoid injuries is prevention, through a firm understanding of anatomy.

Social Responsibilities

With regards to social accountabilities, it is fundamental as a dental professional to uphold a prominent level of appreciation and knowledge for Anatomy, as it has been deemed our bread and butter. A strong foundation in the oral anatomical landmarks, anatomy of the tongue itself and physiology of nerves, will intuitively sanction the immediate recognition and diagnosis of developing abnormalities, post procedure injuries or congenital conditions. It is our responsibility to inform the patient prior to treatment, the risks and frequent injuries that have been associated to said procedure. The attaining of an oral and written, signed consent acknowledging this preceding the treatment has been labelled as instrumental, as any reason given for injury post treatment will appear as an excuse, rather than an effect of the procedure itself. Furthermore, our responsibilities extend to being well acquainted with the protocol of action if a lesion to a nerve is produced and it is our duty to implement said protocol when necessary, as occasionally certain treatments lead to their inevitable injury. Having said that, we cannot negate our liability to fulfil the recommendations to reduce nerve injury outlined by previous dental professionals. Our accountability is the prevention of such lesions where possible, and the limitation of injury through systematic follow up appointments to ensure correct healing. By means of this, reassurance is provided, and trust is established. This in turn provides social sustainability of the patients' mental health, and with full assurance in patient confidentiality, results in respect and stability within the dental profession.

ANNEX

Annex 1- Subjects presenting Lingual Nerve Injury

Subject X attended the clinic for a lower right third molar 48 extraction (39). The treatment went according to plan, however, a week post-surgery the patient returned to the clinic for a follow up appointment complaining of a burning sensation on that very side. In the medical history it was recorded a unilateral, right side lingual atrophy of the fungiform papillae with bite marks from cusp indentation on this right hemi-tongue due to a decrease in proprioception.

Photos were taken, and anti-inflammatory medication was prescribed with monthly follow up appointments scheduled.

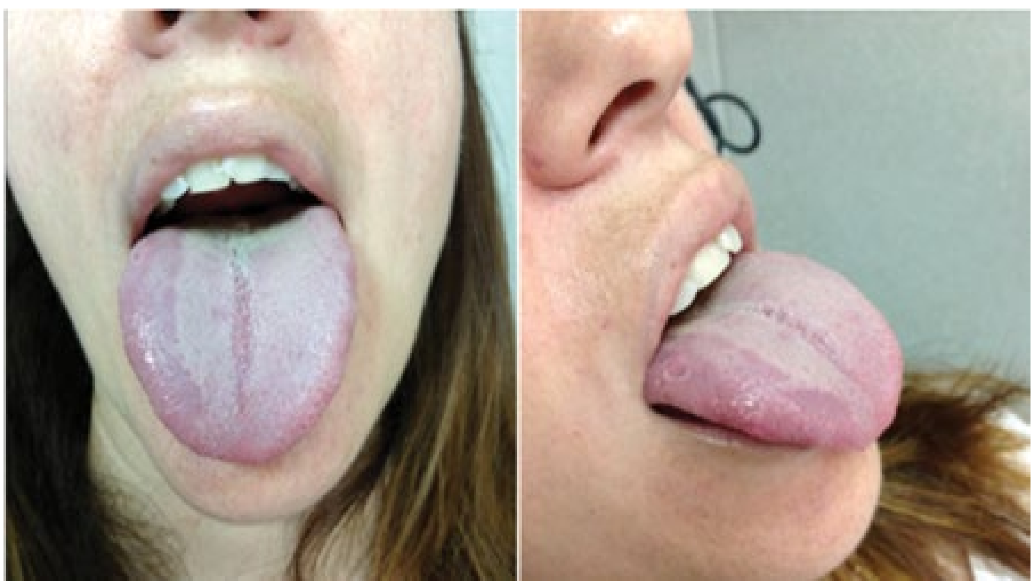


Figure A.1 Frontal and Lateral view of Subject X with the tongue in a protrusive position.

Image taken from Martos-Fernández M, de-Pablo-Garcia-Cuenca A, Bescós-Atín MS. Lingual nerve injury after third molar removal: Unilateral atrophy of fungiform papillae. J Clin Exp Dent. 2014.

Subject X returned to the clinic six months following the surgery (39). A reduction in the size of the atrophied fungiform area was seen despite the persistence of cusp indentations along the tongue's lateral borders. The patient no longer complained of the burning sensation.

Figure A.1 Frontal and Lateral view of Subject X with the tongue in a protrusive position six months following Lingual Nerve injury.

Image taken from Martos-Fernández M, de-Pablo-Garcia-Cuenca A, Bescós-Atín MS. Lingual nerve injury after third molar removal: Unilateral atrophy of fungiform papillae. J Clin Exp Dent. 2014.

Subject Y attended the clinic for Microsurgical repair after being referred to the Oral Maxillofacial Surgeon following a lingual nerve injury (40). The subject presented burning mouth symptomatology, with a large decrease in sensation and taste alterations. These symptoms did not show any improvement in the monthly follow up appointments; thus, surgery was indicated.

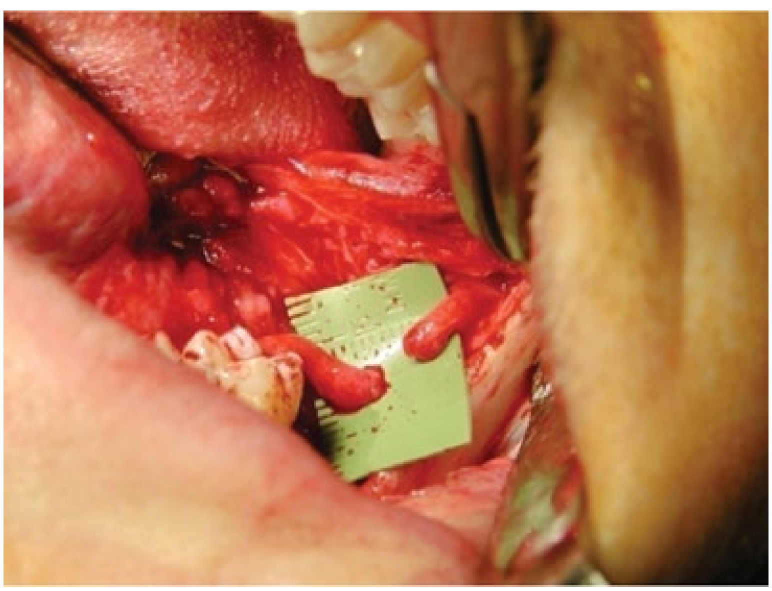


Figure A.2 Frontal view of the left side of Subject Y with an individual exposure of distal and proximal LN Image taken from Bagheri et al. Microsurgical Repair of Lingual Nerve Injuries. J Oral Maxillofac Surg 2010.

Subject Z attended the clinic for a lower right third molar 48 extraction (41). Although the tooth was successfully extracted, the treatment did cause a lingual nerve injury due to the compressive and tractive forces exerted during the operation. During the follow up appointment the subject complained of burning mouth and decreased sensation in certain areas of the tongue, and interestingly hypersensitivity in other areas. Photos were taken, and anti-inflammatory medication was prescribed with monthly follow up appointments scheduled.

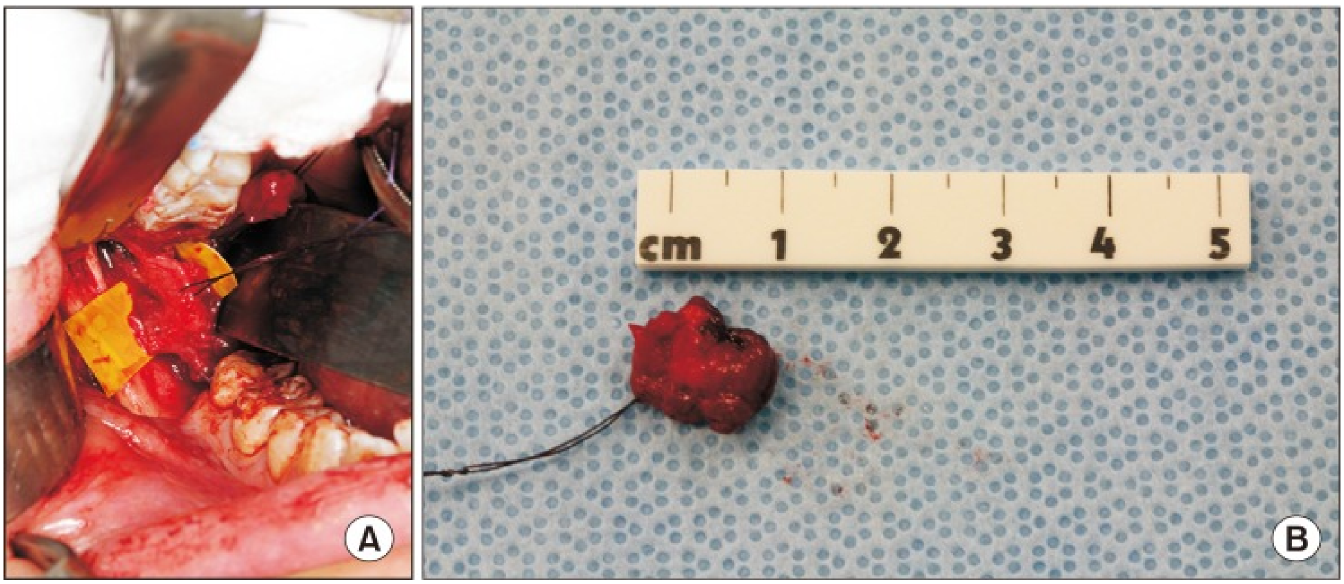


Figure A.3 (A) 3rd Molar surgery resulting in lingual nerve injury with the consequences being reported as anaesthesia, severe hyperaesthesia and dysesthesia (B) 12mm 3rd Molar extracted

Image taken from J Korean Assoc Oral Maxillofac Surg. 2019 Oct; 45(5): 233–240.

Annex 2- Recommendations to avoid LN injury

Prevention is better than rehabilitation

After rigorous article research, the three more notable procedures that have been recorded to produce lingual nerve injury have been included here in an effort to raise awareness and decrease their frequency of occurrence.

Lingual Flap

Lingual nerve damage is under a multifactorial influence following mandibular third molar surgery. Numerous studies presented evidence suggesting the avoidance of the lingual flap technique during surgery, in addition to preserving the lingual plate of the mandible to reduce the incidence of temporary lingual nerve injury (26).

Local Anaesthesia

Further reports have emphasised a connotation between LN injury and high concentration local anaesthetics like Prilocaine 4% and Articaine 4%. Thus, the use of either Lidocaine or Mepivacaine has been advised (26).

The best prevention strategy to avoid iatrogenic LN injury has been collectively agreed upon by numerous articles, and that is to attain an exhaustive knowledge of lingual nerve anatomy and trajectory (35). For example, edentulism and mandibular atrophy results in the LN taking a more superficial, cranial position compared to dentated individuals (35). Therefore, take precautions while performing anaesthesia on said patient.

3rd Molar

Possible LN injury arises from extraction of lower third molar due to the nerve being cut by the rotary instrument during tooth sectioning, compressive or tractive forces. Therefore, it's been recommended to section two thirds of the lower third molar, followed by the use of the universal elevator with the utmost care (26).

Annex 3- Schemes of Rehabilitation Protocol following Lingual Nerve Injury

It is now standard protocol to employ the Clinical Neurosensory Testing to objectively assess the degree of sensory impairment, monitor recovery, and conclusively decide if micro neurosurgery is required (36).

Clinical Neurosensory Testing is implemented through the sequential monitoring of subject response at three individual levels; A, B and C, to assess mechanoceptive and nociceptive response of the affected area.

Level A: evaluated by the professional passing a fine hairbrush on the tongue and asking the patient to detect the direction of movement (right or left).

Level B: evaluated by the professional using a Boley gauge with blunt tips to assess two distinct points of the affected area. For comparative purposes, a third point on an unaffected area is also taken as a control.

Level C: evaluated by the professional using a 27-gauge needle or dental explorer tip and lightly piercing the subject in both the affected and unaffected area to establish a comparison with a control

The subject's response for each level is recorded.

The protocol following LN injury is principally based on whether the injury was caused during treatment or as a follow up appointment, several days post operation.

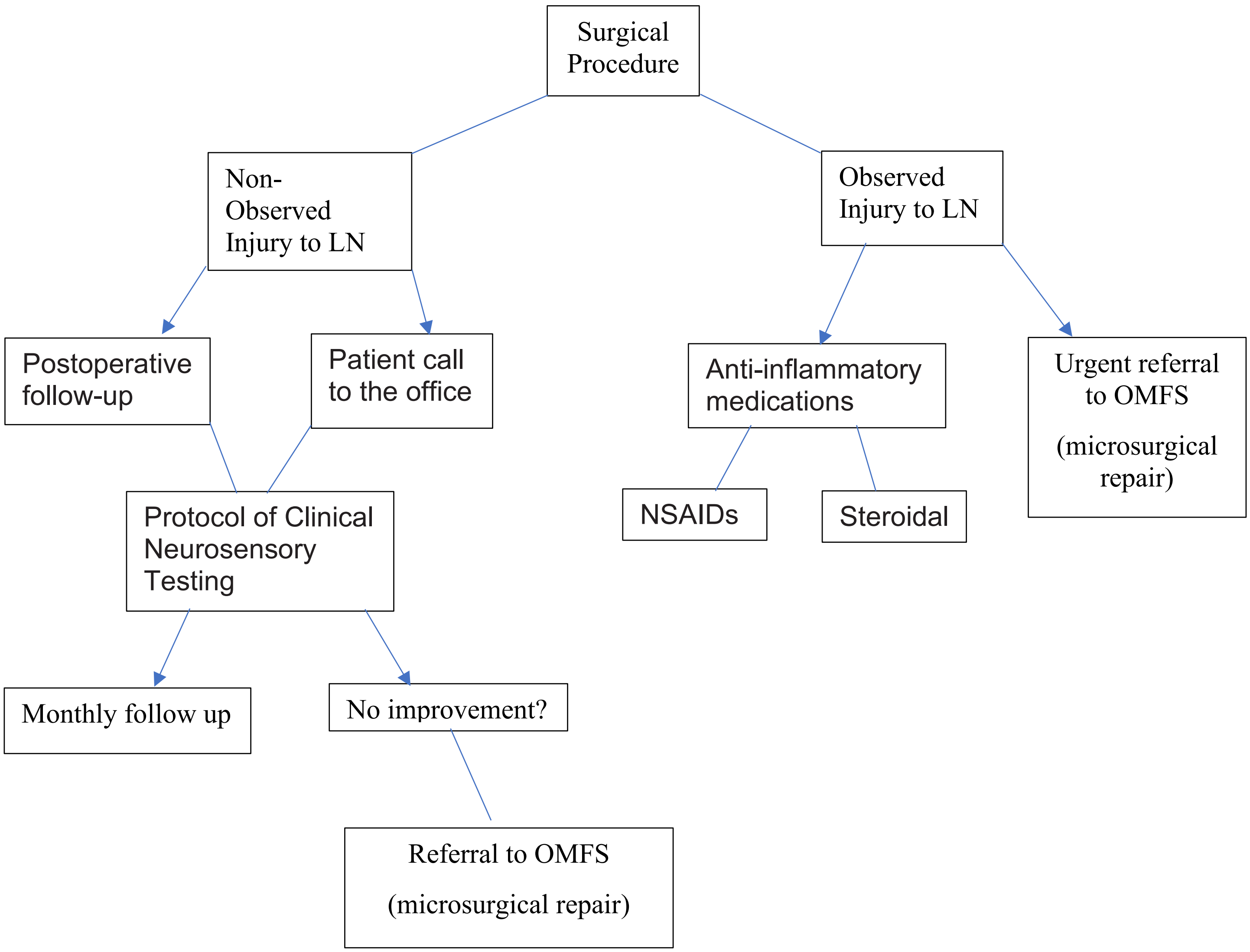
Observed injuries

- Preparation of the documentation for urgent referral to an OMFS specialising in micro-neurosurgical repair
- Prescription of anti-inflammatory medications including steroids, NSAIDs e.g., ibuprofen 800 mg TID for 14 days or Solumedrol Dose Pack, typically a six-day course (37).

Unobserved LN injury

- Either a postoperative follow-up or patient call to the office.
- Conduct a Clinical Neurosensory Test following the sequential order of A, B, C
- Non-affected side tested first for each level to determine patient's normal response
- Affected side then tested, with abnormal responses being mapped out as an outline of an area with altered sensation.
- Classify the injury as: dysesthesia, paraesthesia, hypoesthesia, anaesthesia, hyperaesthesia or paraguesia (alteration of taste sensation)
- Quantify pain on a scale of 1 to 10 on various parts of the tongue and floor of mouth
- Determine whether pain is provoked or spontaneous.
- Quantify decreased sensation on a scale of 1 to 10 and compare with the contralateral side.
- Alterations should be documented (37).

The following protocols above have been represented out below:



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Bolus Formation and Disintegration during Digestion of Food Carbohydrates

Gail M. Bornhorst, R. Paul Singh

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About | Sections

Abstract

Abstract: The first step in the digestion process is mastication, or chewing, when food is broken down, lubricated with saliva, and formed into a cohesive mass known as the food bolus. Upon swallowing, the bolus moves to the stomach and undergoes further breakdown during gastric digestion. The subject of this review is the formation of the food bolus and its subsequent breakdown in the stomach. Bolus formation has been widely studied, especially in terms of food particle size and lubrication. However, information about bolus disintegration is limited, and this review focuses on the breakdown of bread and starch-based foods. Bolus formation and disintegration are key steps in the overall digestion process, as they control the rate at which ingested food components and nutrients are absorbed and released into the body. Information on the rate kinetics of bolus disintegration is necessary in developing a quantitative understanding of the food digestion process.

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Unilateral lingual nerve transection alters jaw-tongue coordination during mastication in pigs

Stéphane J. Montuelle, Rachel A. Olson, ... See all authors

13 APR 2020 // https://doi.org/10.1152/japplphysiol.00398.2019

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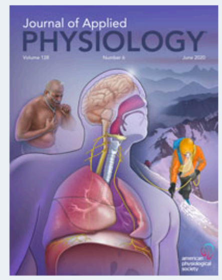
Figures References Related **Information**

Abstract

During chewing, movements and deformations of the tongue are coordinated with jaw movements to manage and manipulate the bolus and avoid injury. Individuals with injuries to the lingual nerve report both tongue injuries due to biting and difficulties in chewing, primarily because of impaired bolus management, suggesting that jaw-tongue coordination relies on intact lingual afferents. Here, we investigate how unilateral lingual nerve (LN) transection affects jaw-tongue coordination in an animal model (pig, *Sus scrofa*). Temporal coordination between jaw pitch (opening-closing) and *1*) anteroposterior tongue position (i.e., protraction-



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Structure and variability in human tongue muscle anatomy

Maureen Stone,[a] Jonghye Woo,[b] Junghoon Lee,[c] Tera Poole,[a] Amy Seagraves,[a] Michael Chung,[a] Eric Kim,[a] Emi Z. Murano,[d] Jerry L. Prince,[e] and Silvia S. Blemker[f]

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Abstract

Go to:

The human tongue has a complex architecture, consistent with its complex roles in eating, speaking and breathing. Tongue muscle architecture has been depicted in drawings and photographs, but not quantified volumetrically. This paper aims to fill that gap by measuring the muscle architecture of the tongue for 14 people captured in high-resolution 3D MRI volumes. The results show the structure, relationships and variability among the muscles, as well as the effects of age, gender and weight on muscle volume. Since the tongue consists of partially interdigitated muscles, we consider the muscle volumes in two ways. The functional muscle volume encompasses the region of the tongue served by the muscle. The structural volume halves the volume of the muscle in regions where it interdigitates with other muscles. Results show similarity of scaling across subjects, and speculate on functional effects of the anatomical structure.

Keywords: Tongue, anatomy, muscles, MRI, 3D, volumes

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The tongue: structure and function relevant to disease and oral health

D F du Toit [1]

Affiliations + expand

PMID: 14964052

Cite

Abstract

The tongue (L. lingua; G. glossa) functions as a digestive organ by facilitating the movement of food during mastication and assisting swallowing. Other important functions include speech and taste. The tongue consists of striated muscle and occupies the floor of the mouth. The dorsal mucosal surface consists of stratified squamous epithelium, with numerous papillae and taste buds. The tongue, a voluntary muscular structure, is attached by a fold, called the frenulum, to the floor of the mouth. Typically, between 8 and 12 circumvallate papillae are arranged in an inverted V-shape towards the base of the tongue. This anatomical review focuses on structure, function relationships and diseases affecting the tongue. From a primary oral health care perspective, this overview will facilitate the process of differential diagnosis in persons presenting with vesiculo-bullous, ulcerative, atrophic and cystic disorders of the tongue. Suspicious lesions should be biopsied to rule out carcinoma.

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Tongues, tentacles and trunks: the biomechanics of movement in muscular-hydrostats

WILLIAM M. KIER, KATHLEEN K. SMITH

Zoological Journal of the Linnean Society, Volume 83, Issue 4, April 1985, Pages 307–324, https://doi.org/10.1111/j.1096-3642.1985.tb01178.x

Published: 28 June 2008 **Article history** ▾

Abstract

Muscular-hydrostats, muscular organs which lack typical systems of skeletal support, include the tongues of mammals and lizards, the arms and tentacles of cephalopod molluscs and the trunks of elephants. In this paper the means by which such organs produce elongation, shortening, bending and torsion are discussed. The most important biomechanical feature of muscular-hydrostats is that their volume is constant, so that any decrease in one dimension will cause a compensatory increase in at least one other dimension. Elongation of a muscular-hydrostat is produced by contraction of transverse, circular or radial muscles which decrease the cross-section. Shortening is produced by contraction of longitudinal muscles. The relation between length and width of a constant volume structure allows amplification of muscle force or displacement in muscular-hydrostats and other hydrostatic systems. Bending requires simultaneous contraction of longitudinal and antagonistic circular, transverse or radial muscles. In bending, one muscle mass acts as an effector of movement while the alternate muscle mass provides support for that movement. Torsion is produced by contraction of muscles which wrap the muscular-hydrostat in a helical fashion.

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Ankyloglossia: the adolescent and adult perspective

M Lauren Lalakea [1], Anna H Messner

Affiliations + expand

PMID: 12748571 DOI: 10.1016/s0194-5998(03)00258-4

Full text links   Cite

Abstract

Objectives: We sought to characterize examination findings and functional limitations due to ankyloglossia in adolescents and adults and to evaluate frenuloplasty in this group. Study design A prospective study was conducted of 15 individuals with ankyloglossia aged 14 to 68 years. Baseline symptoms were recorded by questionnaire, and tongue mobility measures were compared with that of 20 control subjects. Six subjects were reassessed postfrenuloplasty.

Results: Thirteen of 14 patients with uncorrected ankyloglossia (93%) noted symptoms including speech problems (50%) and mechanical limitations (57%), such as difficulty licking the lips. Mean tongue protrusion and elevation at baseline measured 15.5 +/- 6.0 mm and 13.6 +/- 8.0 mm, respectively, for patients and 32.0 +/- 3.9 mm and 30.3 +/- 4.9 mm for control subjects ($P < 0.001$). Postfrenuloplasty, tongue function improved both subjectively and objectively in 6 of 6 patients, with a mean gain of 9.2 mm for protrusion ($P < 0.05$) and 13.0 mm for elevation ($P < 0.001$).

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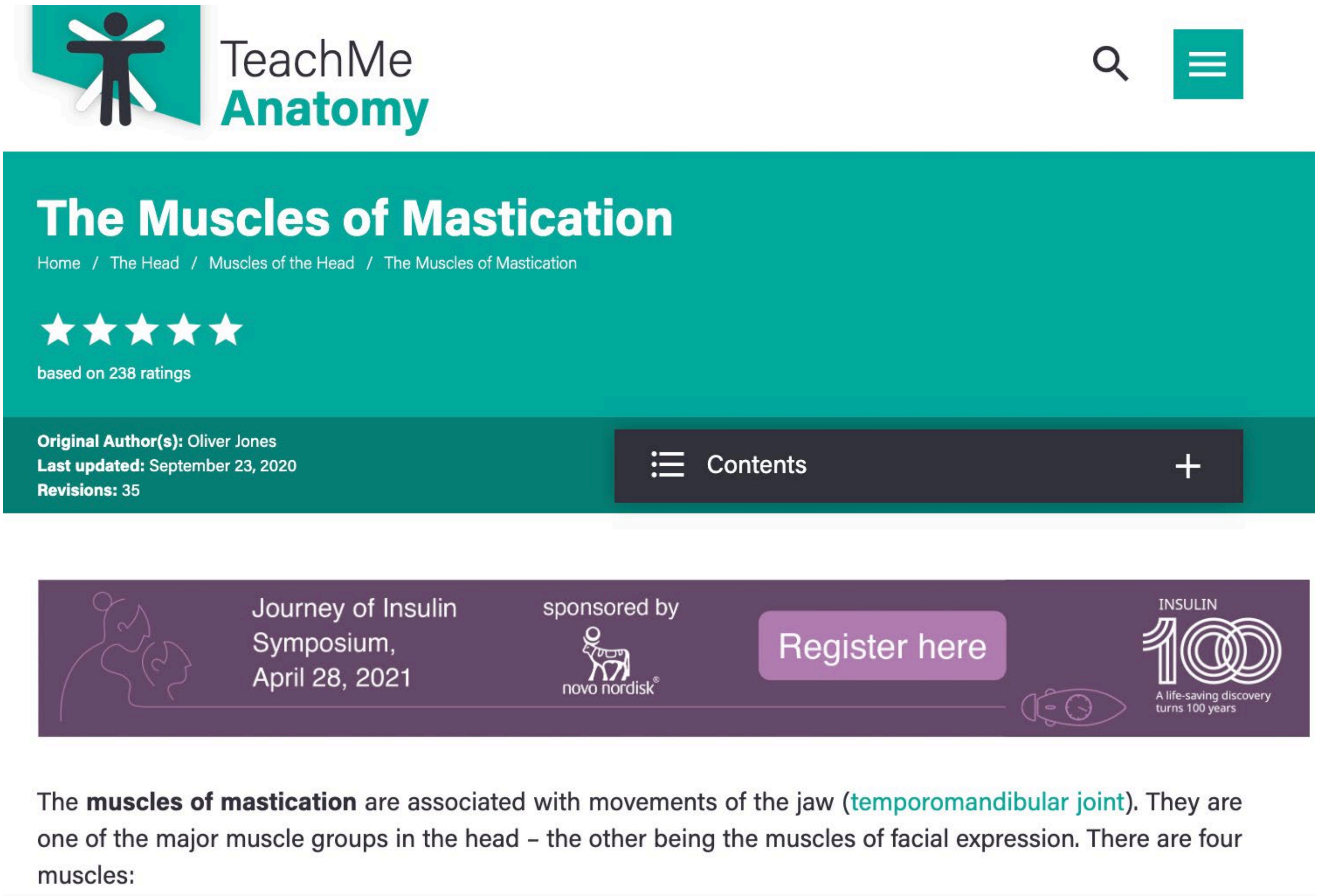
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The Muscles of Mastication

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Original Author(s): Oliver Jones
Last updated: September 23, 2020
Revisions: 35

Contents

The **muscles of mastication** are associated with movements of the jaw (temporomandibular joint). They are one of the major muscle groups in the head – the other being the muscles of facial expression. There are four muscles:

8. Shimokawa T, Akita K, Soma K, Sato T. Innervation analysis of the small muscle bundles attached to the temporalis: truly new muscles or merely derivatives of the temporalis?. Surgical and Radiologic Anatomy. 1999;20(5):329-334.

Surg Radiol Anat (1998) 20: 329-334

Surgical and Radiologic Anatomy
Journal of Clinical Anatomy

Innervation analysis of the small muscle bundles attached to the temporalis: truly new muscles or merely derivatives of the temporalis?

T. Shimokawa[1], K. Akita[2], K. Soma[1] and T. Sato[2]

[1] First Department of Orthodontics, Faculty of Dentistry, Tokyo Medical and Dental University, Tokyo, 113-8549, Japan

[2] Second Department of Anatomy, School of Medicine, Tokyo Medical and Dental University, Tokyo, 113-8519, Japan

Summary: Detailed examinations were performed in ten temporal muscles from five cadavers to identify the muscle bundle arrangements of the temporalis and their innervation. Three additional muscle bundles were clearly observed in the main part of the fan-shaped tempora-

ral et leur innervation. Trois faisceaux musculaire supplémentaires ont clairement été observés dans la partie principale du corps charnu en éventail du muscle temporal : les faisceaux musculaires antéro-médial, antéro-latéral et intermédio-latéral. En raison de leur origine, de leur

Shankland et al. [11] described two muscles as newly-unreported muscles. However, these have been previously described by Eisler [6] as parts of the temporalis m. as based on his detailed innervation investigation. The literature of the anatomy of the masticatory mm. is

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Muscles of the tongue

Assoc Prof Frank Gaillard et al.

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Article information

The **muscles of the tongue** are divided into 2 groups each comprising 4 muscles. They are classified as intrinsic (to the tongue) and extrinsic muscles. They allow for the complex movements of the tongue and are all innervated by the hypoglossal nerve (CN XII) except one:

- intrinsic muscles of the tongue which do not have attachments outside the tongue and who's action is to alter the *shape* of the tongue:
  - superior longitudinal muscle of the tongue
  - inferior longitudinal muscle of the tongue
  - transverse muscle of the tongue
  - vertical muscle of the tongue
- extrinsic muscles of the tongue (mnemonic) which have attachments outside the tongue and therefore their actions alter the *position* of the tongue:
  - genioglossus muscle: the majority of the tongue
  - hyoglossus muscle
  - styloglossus muscle
  - palatoglossus muscle: supplied by the vagus nerve (CN X) via the pharyngeal plexus

Cases and figures

Figure 1

10. Sanders I, Mu L. A Three-Dimensional Atlas of Human Tongue Muscles. The Anatomical Record. 2013;296(7):1102-1114.

A 3-Dimensional Atlas of Human Tongue Muscles

IRA SANDERS[1] and LIANCAI MU[2,*]

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Abstract

Go to:

The human tongue is one of the most important yet least understood structures of the body. One reason for the relative lack of research on the human tongue is its complex anatomy. This is a real barrier to investigators as there are few anatomical resources in the literature that show this complex anatomy clearly. As a result, the diagnosis and treatment of tongue disorders lags behind that for other structures of the head and neck. This report intended to fill this gap by displaying the tongue's anatomy in multiple ways. The primary material used in this study was serial axial images of the male and female human tongue from the Visible Human (VH) Project of the National Library of Medicine. In addition, thick serial coronal sections of three human tongues were rendered translucent. The VH axial images were computer reconstructed into serial coronal sections and each tongue muscle was outlined. These outlines were used to construct a 3-dimensional computer model of the tongue that allows each muscle to be seen in its *in vivo* anatomical position. The thick coronal sections supplement the 3-D model by showing details of the complex interweaving of tongue muscles throughout the tongue. The graphics are perhaps the clearest guide to date to aid clinical or basic science investigators in identifying each tongue muscle in any part of the human tongue.

Keywords: tongue, intrinsic and extrinsic tongue muscles, neuromuscular compartments, tongue movement, speech, swallowing, respiration, 3-D reconstruction

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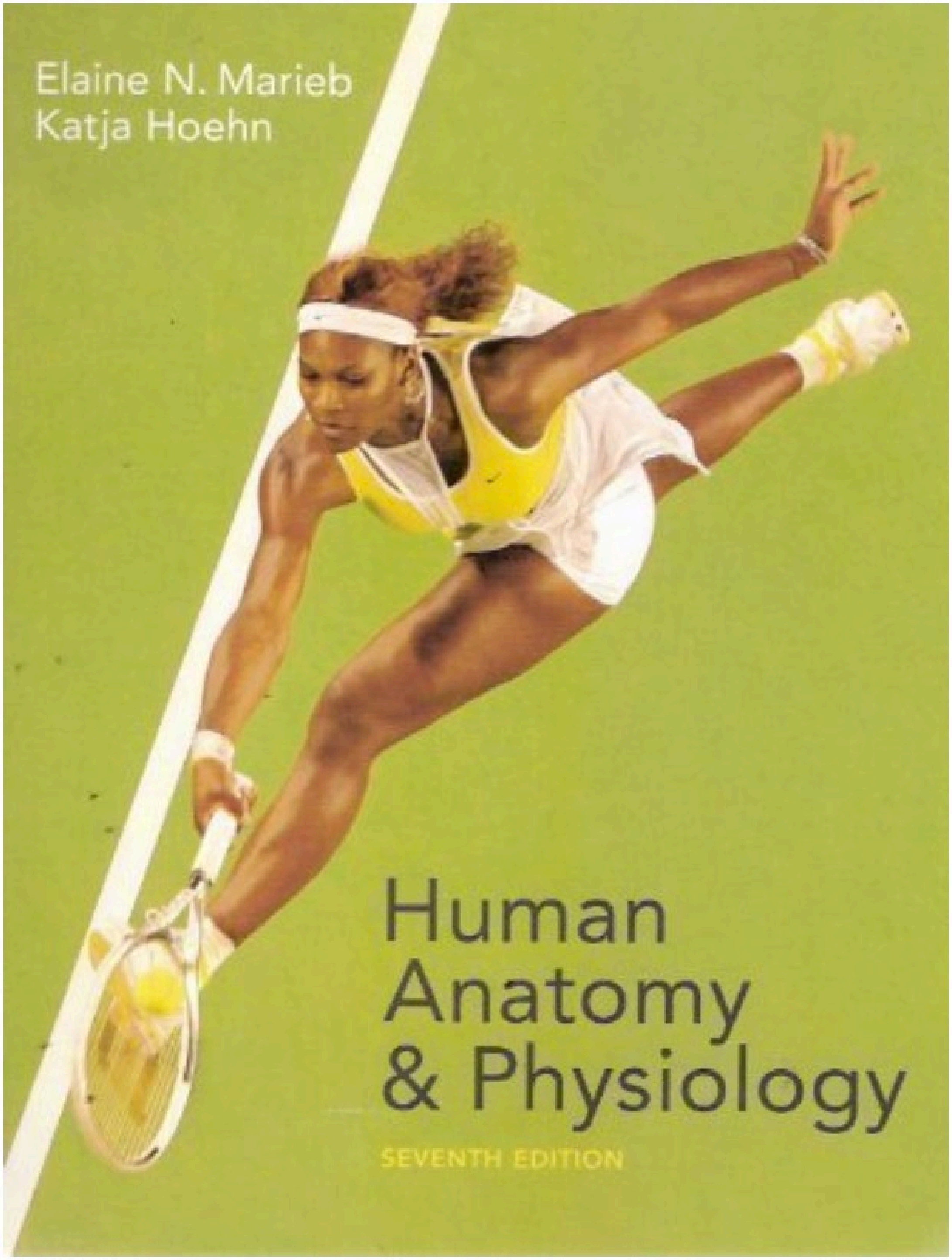

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Anatomy, Head and Neck, Genioglossus Muscle

Tiffany McCausland; Bruno Bordoni.

Author Information

Last Update: February 7, 2021.

Introduction

Go to:

The genioglossus is a paired tongue muscle that is in the group of extrinsic muscles of the tongue. The other extrinsic muscles of the tongue are the hyoglossus (chondroglossus), styloglossus and the palatoglossus.[1][1] All of these extrinsic muscles are within proximity of one another, which is why the entirety of the extrinsic muscle group usually functions as a unit. Each muscle has its individual function, but there tends to be more than one extrinsic muscle functioning at the same time.

Histologically the genioglossus muscle has significant type 2 fibers present in the anterior section of the genioglossus muscle, whereas the posterior portion of the muscles does not have a large portion of type 2 fibers present. The specific fibers present in the particular portion of the genioglossus muscle determine the function of the muscle. For example, the anterior portion of the genioglossus contains type 2 fibers, and this suggests that this portion of the genioglossus muscle participates in phasic action.[2] The posterior portion while it does not contain many type 2 fibers has significant muscle strength compared to the anterior portion of the genioglossus; because of this, it there are sugggestions that the posterior portion of the genioglossus holds responsibility in the nasopharyngeal airway, as well as in the production of the sound of vowels.[2][3][4]

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Anatomy, Head and Neck, Lingual Artery

Jordan Lettau; Bruno Bordoni.

‣ Author Information

Last Update: February 7, 2021.

Introduction

Go to:

The lingual artery, which supplies the tongue as well as the oral floor, is a major branch of the external carotid artery. It appears anteromedially from the external carotid artery, at the tip of the greater horn of the hyoid bone, between the superior thyroid artery and the facial artery.[1] The lingual artery moves medially to the hyoid bone while crossing the hypoglossal nerve (CN XII). It then courses deep to the stylohyoid and digastric muscles while subsequently passing between the middle constrictor and the hyoglossus muscles.[2] As the lingual artery progresses to the tip of the tongue, it branches to supply the adjacent tissues. The major branches of the lingual artery include the suprahyoid artery, the dorsal lingual artery, the sublingual artery, and the deep lingual artery, also known as the ranine artery.[3]

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Oral cavity

Author: Jana Vasković · Reviewer: Nicola McLaren MSc

Last reviewed: April 08, 2021
Reading time: 8 minutes

They don't say for nothing *'health comes first, and it enters through the mouth'.* When we say *'mouth'* we mean the **oral cavity**; a space in the lower part of the head that functions as the entrance to the digestive system.

The content of the oral cavity determines its function. It houses the structures necessary for mastication and speech, which include the teeth, the tongue and associated structures such as the salivary glands. Most of the oral cavity functions are related to the tongue, especially the tongue's muscular and sensory abilities. That's why this page on the anatomy of the mouth will focus on tongue anatomy.

Oral cavity

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Anatomy, Head and Neck, Suprahyoid Muscle

Yusuf S. Khan; Bruno Bordoni.

Author Information

Last Update: February 13, 2021.

Introduction

Go to:

There are many muscles in the neck. One of the classifications of the muscles of the neck is relative to the hyoid bone. Those muscles which are above the hyoid bone are termed as supra-hyoid muscles, and those below it are called infra-hyoid muscles. This group of muscles participates in the processes of chewing, swallowing, and phonetics. Moreover, together with the infrahyoid muscles, they contribute to the fixation of the hyoid bone, which does not articulate with any other bone. The suprahyoid muscles participate in improving the flexion movement of the neck.

The supra-hyoid muscles are between the two bony landmarks, the base of the mandible above and the hyoid bone below. They are in pairs of four present on each side of the midline of the neck, named as follows

1. Digastric
2. Stylohyoid
3. Mylohyoid
4. Geniohyoid

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Three-dimensional architecture of the intrinsic tongue muscles, particularly the longitudinal muscle, by the chemical-maceration method

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Affiliations + expand

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Abstract

Muscle bundles of the transverse and vertical muscles of the tongue become flat when they enter the longitudinal muscle layers of the tongue, where they form a tunnel-like structure that surrounds the longitudinal muscle of the tongue. However, the three-dimensional architecture of longitudinal muscle fibers of the tongue has not been clarified. In the present study, we evaluated the function of the intrinsic muscles of the tongue by studying the three-dimensional architecture of the longitudinal muscle. Muscle bundles of the longitudinal muscle of the anterior part of a rabbit's tongue were exposed by the chemical-maceration and modified chemical-maceration methods and examined by scanning electron microscopy. In the longitudinal muscle of the tongue, muscle bundles running in the anteroposterior direction were arranged at regular intervals. These muscle bundles bifurcated or ramified at a sharp angle at each level from the superficial layer to the deep layer and joined or fused with adjacent muscle bundles. In addition, these ramified muscle bundles ran obliquely into shallower or deeper layers of the muscle, as well as in the same plane. Consequently, the longitudinal muscle of the tongue as a whole had a three-dimensional mesh-like structure. The transverse and vertical muscles of the tongue entered this mesh-like structure of muscle bundles of the longitudinal muscle as flat muscle bundles. The transverse and vertical

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TONGUE MOVEMENTS IN FEEDING AND SPEECH

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ABSTRACT: The position of the tongue relative to the upper and lower jaws is regulated in part by the position of the hyoid bone, which, with the anterior and posterior suprahyoid muscles, controls the angulation and length of the floor of the mouth on which the tongue body 'rides'. The instantaneous shape of the tongue is controlled by the 'extrinsic muscles' acting in concert with the 'intrinsic' muscles. Recent anatomical research in non-human mammals has shown that the intrinsic muscles can best be regarded as a 'laminated segmental system' with tightly packed layers of the 'transverse', 'longitudinal', and 'vertical' muscle fibers. Each segment receives separate innervation from branches of the hypoglosssal nerve. These new anatomical findings are contributing to the development of functional models of the tongue, many based on increasingly refined finite element modeling techniques. They also begin to explain the observed behavior of the jaw-hyoid-tongue complex, or the hyomandibular 'kinetic chain', in feeding and consecutive speech. Similarly, major efforts, involving many imaging techniques (cinefluorography, ultrasound, electro-palatography, NMRI, and others), have examined the spatial and temporal relationships of the tongue surface in sound production. The feeding literature shows localized tongue-surface change as the process progresses. The speech literature shows extensive change in tongue shape between classes of vowels and consonants. Although there is a fundamental dichotomy between the referential framework and the methodological approach to studies of the orofacial complex in feeding and speech, it is clear that many of the shapes adopted by the tongue in speaking are seen in feeding. It is suggested that the range of shapes used in feeding is the matrix for both behaviors.

Key words. Tongue, regional anatomy, eating, speech, deglutition.

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Kinematic linkage of the tongue, jaw, and hyoid during eating and speech

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Abstract

Objective: Tongue movement is temporo-spatially coordinated with jaw and hyoid movements during eating and speech. As such, we evaluated: (1) the correlation between the tongue with jaw and hyoid movements during eating and speech and (2) the relative influence of the jaw and hyoid on determining tongue movement.

Design: Lateral projection videofluorography was recorded while 16 healthy subjects ate solid foods or read a standard passage. The position of anterior and posterior tongue markers (ATM and PTM, respectively), the jaw, and the hyoid relative to the upper occlusal plane was quantified with the upper canine as the origin (0,0) point for Cartesian coordinates. For vertical and horizontal dimensions, separate multiple linear regression analyses were performed with ATM or PTM position as a function of jaw and hyoid positions.

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The tongue in speech and feeding: Comparative articulatory modelling

November 2012 · Journal of Phonetics 40(6)
DOI: 10.1016/j.wocn.2012.08.001

Antoine Serrurier · Pierre Badin · Anna Barney · Show all 5 authors ·
Christophe Savariaux

Abstract

Purpose: Two of the major functions of the human vocal tract are feeding and speaking. As ontogenetically and phylogenetically feeding tasks precede speaking tasks, it has been hypothesised that the skilled movements of the orofacial articulators specific to speech may have evolved from feeding functions. Our objective is to bring evidence to support this hypothesis. Method: Vocal tract articulatory measurements on a male subject have been recorded for speech and feeding by Electromagnetic Articulography. Two linear articulatory models of the jaw/tongue system have been built through statistical analysis for both speech and feeding tasks. Results: The two articulatory models show similar reconstruction accuracy, with 97% and 99% of the variance explained by the five parameters of each model. The speech articulations can be reconstructed from the feeding model with a Root Mean Square error of +0.05 cm

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Tongue–jaw linkages in human feeding: a preliminary videofluorographic study

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Abstract

Motions of the tongue and jaw are closely coupled during feeding in mammals, but this relation has not been studied in humans. A videofluorographic method for measuring tongue movement relative to jaw motion using small radiopaque markers affixed to the tongue with dental adhesive was developed and tested in five individuals. Sagittal movements of the anterior tongue marker (ATM) and the lower jaw were measured for complete feeding sequences with a computerized image-analysis system. The ATM and jaw moved in loosely linked, semirhythmic cycles. Vertical and horizontal maxima of ATM motion were determined for each motion cycle in relation to maximum and minimum gape (greatest jaw opening and closing, respectively). The amplitude of tongue movements and their timing differed between hard and soft foods ($p < 0.001$). For both food types, motions varied as the feeding sequence progressed from ingestion to terminal swallow ($p < 0.001$). A basic temporal sequence was found in 70% of the 224 cycles analysed. On average, the ATM reached its most inferior position just after maximum gape, its most posterior during jaw closing, its most superior just after minimum gape, and its most anterior during jaw opening ($p < 0.001$). This study confirms that tongue and jaw movements are linked during human feeding, as they are in other mammals.

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Physiology and Radiology of the Normal Oral and Pharyngeal Phases of Swallowing

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During the past decade, considerable interest has developed in the radiologic examination of the oral and pharyngeal phases of swallowing [1]. This interest has been stimulated by advances in swallowing therapy. In this report, we review (1) the normal physiology of swallowing, (2) methods for radiologic examination of the mouth and pharynx, and (3) the radiologic appearance of normal oral and pharyngeal swallowing. See pages 965–974 for a report on abnormalities of swallowing and therapeutic techniques designed to improve abnormal oral and pharyngeal swallowing functions.

Normal Physiology

Swallowing normally occurs as an orderly physiologic process that transports ingested material and saliva from the mouth to the stomach [2, 3]. This process usually occurs so smoothly and effortlessly that it belies the complexity of the neuromuscular apparatus that executes and orchestrates the swallowing sequence. Generally, swallowing is considered to be voluntary because deglutition can be elicited by cerebral input when one thinks "swallow." Many swallows, however, particularly those between meals, occur without conscious input. Spontaneous swallowing occurs at about 1/min in awake subjects [4]. This high swallowing rate is initiated by salivation, which occurs at about 0.5 ml/min and must either be swallowed or expectorated. The high basal rate of swallowing during wakefulness leads to about 1000 swallows daily or 3 to 4 million per decade. Although the majority of swallows occur subconsciously in response to salivation, some saliva swallows are voluntary, and close clustering of voluntary swallows is evoked consciously during eating. During eating, swallowing is associated with increased salivation, which facilitates the initiation of swallowing and acts as a lubricant. During sleep, salivation and swallows nearly cease [5], but the awake pattern recurs rapidly during arousals from sleep.

Phases of Swallowing

For descriptive purposes, swallowing is divided into four phases: (1) preparatory phase, (2) oral phase, (3) pharyngeal phase, and (4) esophageal phase. The preparatory phase involves mastication of a bolus and mixing it with saliva. The bolus is sized, shaped, and positioned on the tongue ready for swallowing. During the oral phase, the bolus is propelled from the oral cavity into the pharynx. The normal pharyngeal phase involves bolus transport from the oropharynx into the esophagus without aspiration. During the esophageal phase, not discussed further in this report, the bolus is propelled the length of the esophagus into the stomach.

Anatomy

The anatomic components of the head and neck swallowing apparatus include (1) bony and cartilaginous support structures, (2) striated muscles, and (3) neural elements. The bony

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Evaluation of factors predictive of lingual nerve injury in third molar surgery

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Abstract

The aim of this study was to investigate risk factors for temporary and permanent lingual nerve injury after extraction of mandibular third molars. It was based on a 4-year prospective study of 2134 consecutive mandibular third molar operations in 1384 consecutive day case patients. During the study period (1994-1998) data were collected prospectively on patient, dental and surgical factors and correlated with lingual nerve injury using Student's t test, xi(2) and multiple logistic regression analysis. The incidence of temporary and permanent lingual nerve injury was 1 and 0.3%, respectively, per tooth. Factors that predicted temporary and permanent lingual nerve injury by univariate analysis were age, depth of application, difficulty of operation, surgeon and surgical technique used. Independent risk factors identified by multivariate analysis for temporary lingual nerve injury were perforation of the lingual plate, exposure of the nerve and increased difficulty of operation. The predictors for permanent lingual nerve injury in order of importance were perforation of the lingual plate, surgeon, increased difficulty of operation, exposure of the nerve and increased age of the patient. Surgical factors are the main contributors to lingual nerve injury during third molar extraction, but patient and dental factors are also involved.

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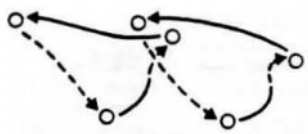
Chapter 14



Mastication, Food Transport, and Swallowing

Karen M. Hiiemae
Alfred W. Crompton

Food has metabolic value only when the products of its digestion enter the blood stream. For most mammals a high metabolic rate depends on regular ingestion of food items, which in most cases must be mechanically broken down in the oral cavity before they can be chemically simplified in the gut. Thus, food is taken into the mouth (ingestion), processed (mastication), and then swallowed (deglutition). Enzymes in the saliva of most mammals begin to act as the material is readied for swallowing and, depending on the rate of both gastric secretion and gastric movements, continue to act for a limited time. Although some living reptiles shred or puncture food before swallowing (Throckmorton, 1976, 1980; Smith, 1982), that process can be seen as facilitating food intake and swallowing, rather than as producing the extensive mechanical reduction of food within the oral cavity that is characteristic of mammals.

Chewing, or mastication, serves two functions: first, material is reduced to a condition suitable for swallowing; second, the resulting increase in surface area facilitates the penetration of the digestive enzymes and so expedites the rate of chemical breakdown. Foods with resistant cell walls, such as grasses, require extensive mechanical breakdown before digestive enzymes are maximally effective. It is also necessary to expose the cellulose cell walls to the digestive enzymes of bacteria.

Studies of feeding mechanisms in mammals have concentrated on the morphology, or both the morphology and function, of the jaw apparatus (including teeth, mandibular joint, and elevator muscles) in relation to broad dietary habits (for example, Hiiemae and Ardran, 1968; Turnbull, 1970; Kallen and Gans, 1972; Herring and Scapino, 1974; Weijs and Dantuma, 1975; Weijs and de Jongh, 1977; Gorniak, 1977; Janis, 1979; Hylander, 1977, 1979; Fish and Mendel, 1983; Oron and Crompton, unpublished data). Further, the teeth of mammals (and other dentate vertebrates) vary widely in shape, and there are unequivocal associations between tooth form and general dietary habits. It is not, therefore, surprising that teeth and jaws have major taxonomic significance, especially in the analysis of the fossil record, and that much experimental effort has been devoted to analyzing the movements of jaws in feeding.

Mammalian mastication can be characterized (except in some highly specialized forms) as having the following features: (1) active breakdown of food is unilateral, that is, it occurs on one side of the jaw at any one time; (2) there is some element of transverse movement during food breakdown, which is minimal in carnivores and maximal in some herbivores; and (3) upper and lower molars accurately "fit" one another, although their tight occlusion is, to some extent, developed with wear. These features are found in the jaw apparatus of the earliest mammals (known from 180 million years before Pleistocene) and sharply separate them from their immediate ancestors, the mammallike reptiles.

Limited attention (for instance, Hiiemae and Ardran, 1968; Weijs, 1975, for rats; Gordon, 1984, for walruses) has been paid to the mechanisms involved in the ingestion of food or its

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Influence of Bolus Volume on Swallow-Induced Hyoid Movement in Normal Subjects

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Mark K. Kern[1]

Swallowing normally elicits a superior-anterior excursion of the hyoid that contributes to elevation of the larynx and opening of the upper esophageal sphincter. The magnitude of hyoid movements, however, has not been quantitated with respect to the volume of the swallowed bolus. In this study, we determined the magnitude of superior and anterior movements of the hyoid associated with swallows of barium of different volumes. Lateral videoradiographic images of 2- to 20-ml boluses of barium were obtained in 15 subjects who had no pharyngoesophageal symptoms and had normal pharyngoesophageal motor function. Analysis indicated that a significant direct correlation existed between the volume of the swallowed bolus and the magnitude of the superior and anterior movements of the hyoid. For example, the mean values for these respective movements were 13.0 ± 5 mm and 13.5 ± 6 mm for a 2-ml bolus, compared with 14.8 ± 5 mm and 16.7 ± 5 mm for a 10-ml bolus.

The findings indicate that values of deglutitive movement of the hyoid need to be indexed to the volume of the swallowed bolus. The results imply that the neural program in the brainstem that generates the oral and pharyngeal phases of swallowing is not completely stereotyped, but rather is modulated by volume-dependent sensory feedback.

During swallowing, the hyoid makes a pronounced superior and anterior excursion that is thought to enhance pharyngeal filling, retard laryngeal aspiration, and promote opening of the pharyngoesophageal sphincter [1–3]. Our purpose in this study was to (1) quantitate movement of the hyoid associated with normal swallows of barium and recorded by videoradiography and (2) determine whether the magnitude of these movements is affected by the volume of the swallowed bolus.

Subjects and Methods

We obtained videoradiographic studies of the pharynx in 15 subjects who were referred for an upper gastrointestinal series for complaints unrelated to the pharynx or esophagus. In each subject, the radiographic examination of pharyngoesophageal motor function and morphology was judged to be normal. Furthermore, abnormal findings were not seen in the stomach or duodenum. The subjects included nine men and six women; their average age was 39 years (standard deviation [SD], 19 years; range, 20–82). The study was approved by the Human Research and Review Committee of the Medical College of Wisconsin.

Video recordings of the pharynx and cervical esophagus were obtained in the lateral projection while the subjects sat upright and held their heads in a neutral position. We used a 9-in. (23-cm) image intensifier and appropriate collimation. Imaging was done at 80–90 KeV without a grid. In each subject, we recorded swallows of high-density (250% wt/vol) barium (E-Z-EM Inc., Westbury, NY) by using volumes of 2, 5, 10, 15, and 20 ml at room temperature. Also, "dry" swallows were recorded after the pharynx was coated with barium. Swallows for each volume were recorded in duplicate. The fluoroscopy time for each sequence was ≤8 sec, and total fluoroscopy time was limited to 2 min or less. We recorded each swallow sequence on 0.5-in. (1.3-cm) tape using a Beta video recorder (Sony SLHF 900) run at 30 frames/sec. The video unit was coupled with a clock timer (Thalner Electronics, Ann Arbor,

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Anatomy, Head and Neck, Lingual Nerve

Sarah E. Fagan; William Roy.

Author Information

Last Update: August 24, 2020.

Introduction

Go to:

The lingual nerve branches from the mandibular division of the trigeminal nerve. The lingual nerve is often in a common stem with the inferior alveolar nerve after the mandibular division enters the infratemporal fossa through foramen ovale.[1] The lingual nerve separates from the inferior alveolar nerve and then descends anteriorly into the oral cavity. As it does so, it innervates the mucous membrane of the anterior two-thirds of the tongue, the floor of the oral cavity, and the adjacent gum (lingual gingiva).[2]

Structure and Function

Go to:

After branching from the mandibular nerve high in the infratemporal fossa, the lingual nerve passes between the tensor veli palatini and lateral pterygoid muscles. It then emerges from between the lateral and medial pterygoid muscles anterior to the inferior alveolar nerve.[3] The nerve passes between the lateral surface of the medial pterygoid muscle and the mandibular ramus en route to the oral cavity. As it courses anteriorly adjacent to the mandible, the lingual nerve gives innervation to several structures, including the mandibular gum (gingiva), the mucous membrane of the anterior two-thirds of the tongue, and the floor of the mouth. [4] The nerve loops under the submandibular duct as it passes toward the apex of the tongue.[2]

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Functional anatomy of the mandibular nerve: Consequences of nerve injury and entrapment

Maria Piagkou, Theano Demesticha, Panayiotis Skandalakis, Elizabeth O. Johnson

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Abstract

Various anatomic structures including bone, muscle, or fibrous bands may entrap and potentially compress branches of the mandibular nerve (MN). The infratemporal fossa is a common location for MN compression and one of the most difficult regions of the skull to access surgically. Other potential sites for entrapment of the MN and its branches include, a totally or partially ossified pterygospinous or pterygoalar ligament, a large lamina of the lateral plate of the pterygoid process, the medial fibers of the lower belly of the lateral pterygoid muscle and the inner fibers of the medial pterygoid muscle. The clinical consequences of MN entrapment are dependent upon which branches are compressed. Compression of the MN motor branches can lead to paresis or weakness in the innervated muscles, whereas compression of the sensory branches can provoke neuralgia or paresthesia. Compression of one of the major branches of the MN, the lingual nerve (LN), is associated with

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Distribution pattern of the human lingual nerve

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Affiliations + expand

PMID: 14974094 DOI: 10.1002/ca.10166

Abstract

The tongue is an intricate organ with many functions. Despite the knowledge of the presence of muscular and neural connections in the tongue, a detailed neuroanatomical depiction of the nerves' topography in the tongue has not been demonstrated. The topography, branching patterns and neuronal interconnections of the lingual nerve were studied in five postmortem human tongues. They were stained with Sihler's stain, a technique that renders most of the tongue tissue translucent while counterstaining nerves. The lingual nerve reaches the tongue posterolaterally. There are two main branches off of the main trunk: the medial branch sends 2-4 small branches to the medial part of the ventrolateral tongue and the lateral branch runs along the lateral tongue border and sends 3-4 large branches to the anterior tip of tongue. Each subdivision gives off 2-5 distal branches. Both medial and lateral branches have interconnections with the proximal part of the hypoglossal nerve. One of the unexpected discoveries in this study was the high density of nervous fibers in the lateral aspect of the tongue as compared to the midline region. The average diameter of the main trunk of the lingual nerve is 3.5 mm. The medial and lateral branches average 1 mm in diameter, the more distal subdivisions measure 0.5-0.75 mm, and the lingual-hypoglossal interconnections measure 0.125-0.250 mm. In summary, this study provides the first detailed depiction of the topography of the human lingual nerve and its branches in situ, confirmation of

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Lingual Nerve Injury: Surgical Anatomy and Management

June 4, 2018

by Yasser Alali, DDS MSc (candidate); Harshdeep Mangat, BSc, MD, DMD, MSc; Marco F. Caminiti, BSc, DDS, Med, FRCD(C)

Introduction

The Lingual nerve (LN) is a branch of the mandibular division of the trigeminal nerve (V3) that is responsible for general somatic afferent (sensory) innervation. It supplies the mucous membranes of the mandibular lingual gingiva, floor of the mouth and the ipsilateral two-thirds of the tongue. *1* It also carries specialized taste fibers and parasympathetic innervation to salivary glands. While it should be an infrequently encountered nerve during routine and basic oral and maxillofacial surgical procedures encountered in daily dental practices, its vulnernable position poses a risk of iatrogenic injury. The purpose of this paper is to enlighten readers with regard to the anatomy of this nerve in light of potential risks, which unfortunately are not uncommon. Unfortunately, current treatment options yield minimal success in the improvement or restoration of function of the lingual nerve following injury.

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A retrospective analysis of lingual nerve sensory changes after mandibular bilateral sagittal split osteotomy

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Affiliations + expand

PMID: 9632327 DOI: 10.1016/s0278-2391(98)90799-6

Abstract

Purpose: The purpose of this retrospective study was to determine the patient-reported incidence, duration, and perceived deficit in daily activities associated with lingual nerve (LN) sensory changes after bilateral sagittal split osteotomy (BSSO) of the mandible and to compare them with inferior alveolar nerve (IAN) sensory changes in the same study population.

Materials and methods: Questionnaires were mailed to 316 patients who had undergone BSSO procedures between 1980 and 1993. The patients were queried for perceived sensory changes in the distribution of the IAN and LN; duration of these sensory changes; and alteration in daily activities caused by these sensory changes. The same questionnaire was mailed to 47 patients who had undergone isolated genioplasty (GP) to control for the normal variance of non-BSSO surgery on perceived LN sensory changes.

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Pharyngeal swallowing dysfunction following treatment for oral and pharyngeal cancer—Association with diminished intraoral sensation and discrimination ability

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First published: 21 August 2008 | https://doi.org/10.1002/hed.20881 |

Abstract

Background.

Swallowing disorders following treatment for oral and pharyngeal cancer are mainly considered a surgical sequel. The recent finding that radiotherapy-induced decline in intraoral sensory abilities established an incentive to elucidate any association between the degree of sensory decline and the degree of swallowing dysfunction.

Methods.

Oral and pharyngeal swallowing was cineradiographically examined in 15 patients with oral or pharyngeal cancer before and after treatment. The patients were also tested for intraoral sensation, shape recognition, and hole

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Evidence-based outcomes following inferior alveolar and lingual nerve injury and repair: a systematic review

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PMID: 26059454 DOI: 10.1111/joor.12313

Abstract

The inferior alveolar nerve (IAN) and lingual (LN) are susceptible to iatrogenic surgical damage. Systematically review recent clinical evidence regarding IAN/LN repair methods and to develop updated guidelines for managing injury. Recent publications on IAN/LN microsurgical repair from Medline, Embase and Cochrane Library databases were screened by title/abstract. Main texts were appraised for exclusion criteria: no treatment performed or results provided, poor/lacking procedural description, cohort <3 patients. Of 366 retrieved papers, 27 were suitable for final analysis. Treatment type for injured IANs/LNs depended on injury type, injury timing, neurosensory disturbances and intra-operative findings. Best functional nerve recovery occurred after direct apposition and suturing if nerve ending gaps were <10 mm; larger gaps required nerve grafting (sural/greater auricular nerve). Timing of microneurosurgical repair after injury remains debated. Most authors recommend surgery when neurosensory deficit shows no improvement 90 days post-diagnosis. Nerve transection diagnosed intra-operatively should be repaired in situ; minor nerve injury repair can be delayed. No consensus exists regarding optimal methods and timing for IAN/LN

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Retrospective review of microsurgical repair of 222 lingual nerve injuries

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PMID: 20036042 DOI: 10.1016/j.joms.2009.09.111

Abstract

Purpose: Injury to the lingual nerve (LN) is a known complication associated with several oral and maxillofacial surgical procedures. We have reviewed the demographics, timing, and outcome of microsurgical repair of the LN.

Materials and methods: A retrospective chart review was completed of all patients who had undergone microsurgical repair of the LN by one of us (R.A.M.) from March 1986 through December 2005. A physical examination, including standardized neurosensory testing, was completed of each patient preoperatively. All patients were followed up periodically after surgery for at least 1 year, with neurosensory testing repeated at each visit. Sensory recovery was determined from the patient's final neurosensory testing results and evaluated using the guidelines established by the Medical Research Council Scale. The following data were collected and analyzed: patient age, gender, nerve injury etiology, chief sensory complaint (numbness or pain, or both), interval from injury to surgical intervention, intraoperative findings, surgical procedure, and neurosensory status at the final evaluation. The patients were classified according to whether they achieved "useful sensory recovery" or better, according to the Medical Research Council Scale, or

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Permanent sensory nerve impairment following third molar surgery: a prospective study

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Objective. This prospective study reports the proportion of permanent sensory impairment of the inferior alveolar and lingual nerves and the factors influencing such prevalence after the removal of mandibular third molars under local anesthesia.

Study design. There were 1,087 patients with 1,087 mandibular third molars removed under local anesthesia from 1998 to 2003. Standardized data collection included the patient's name, age, gender, radiographic position of extracted tooth, grade of surgeon, proximity of the inferior alveolar nerve, and the prevalence of lingual and/or inferior alveolar nerve paresthesia.

Results. Inferior alveolar nerve injury was 4.1% 1 week after surgery and decreased to 0.7% after 2 years of follow-up, and alteration in tongue sensation occurred in 6.5% of patients 1 week after surgery and decreased to 1.0% after 2 years of follow-up.

Conclusion. The experience of the operator was found to be a significant factor in determining both permanent lingual nerve (P=.022) and permanent inferior alveolar nerve paresthesia (P=.026). **(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;102:e1-e7)**

Injuries to the lingual nerve (LN) and inferior alveolar nerve (IAN) are well recognized complications of third molar surgery. In previous studies, the prevalence of damage to the IAN during lower third molar surgery has been reported as varying from 0.4%[1] to 8.4%[2] and to the LN as varying from 0%[3] to 23%.[4]

The IAN travels within the mandibular bone and is therefore a supported nerve. Following injury, the nerve will remain in position and regenerate in a relatively short time unless either displaced into the socket or displaced by fragments of bone from the roof of the canal. Thus, after injury to the IAN, good recovery is generally expected.[5] The anatomic relationship between the IAN and the roots of the third molar teeth has also been shown to help predict the likelihood of nerve injury radiographically.[6-8]

After injury, the LN ends tend to retract and become trapped within scar tissue which may require surgical repair, although the success rate of this procedure has so far been modest.[5]

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Oral surgery: part 4. Minimising and managing nerve injuries and other complications

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Abstract

Many post-operative complications can be avoided with good patient selection, training and surgical planning. Obtaining explicit patient consent is also an essential component of treatment. The most significant complications from oral surgical interventions are iatrogenic trigeminal nerve injuries, which can result in permanent altered sensation and pain, causing considerable functional and psychological disability. This paper provides some useful suggestions on minimising the risks of these injuries. By understanding the risk factors and modifying the resulting intervention, more of these injuries may be prevented.

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Topographic anatomy of the lingual nerve and variations in communication pattern of the mandibular nerve branches

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Abstract

We made a thorough observation of the morphology and course of the lingual nerve (LN) and inferior alveolar nerve (IAN) to clarify their topographical relationships in the infratemporal fossa and in the paralingual area. Thirty-two Korean hemi-sectioned heads were dissected macroscopically and microscopically from a clinical viewpoint. On the 32 tracings on the radiograph, the average distance between the retromolar portion and the LN was 7.8 mm, and no case was found where the LN ran above the alveolar crest as passing along the mandibular lingual plate. The bifurcation of the LN and IAN was located around the mandibular notch, inferior to the otic ganglion in 66% of the cases, and a plexiform branching pattern of the mandibular nerve was observed in only two cases. The bifurcation spot of the LN and IAN was located 14.3 mm inferior to the foramen ovale and 16.5 mm superior to the tip of hamulus. Collateral nerve twigs from the LN to the retromolar area were observed in 26 cases (81.2%), with an average of one nerve twig. We observed four types of variations in terms of communication pattern. In four specimens, the

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Prevention of iatrogenic inferior alveolar nerve injuries in relation to dental procedures

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Abstract

This article aims to review current hypotheses on the aetiology and prevention of inferior alveolar nerve (IAN) injuries in relation to dental procedures. The inferior alveolar nerve can be damaged during many dental procedures, including administration of local anaesthetic, implant bed preparation and placement, endodontics, third molar surgery and other surgical interventions. Damage to sensory nerves can result in anaesthesia, paraesthesia, pain, or a combination of the three. Pain is common in inferior alveolar nerve injuries, resulting in significant functional problems. The significant disability associated with these nerve injuries may also result in increasing numbers of medico-legal claims. Many of these iatrogenic nerve injuries can be avoided with careful patient assessment and planning. Furthermore, if the injury occurs there are emerging strategies that may facilitate recovery. The emphasis of this review is on how we may prevent these injuries and facilitate resolution in the early post surgical phase.

Clinical relevance: It is imperative that dental practitioners are aware of the significant disability associated with iatrogenic nerve injuries and have an awareness of risk factors relating to inferior

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Lingual flap retraction and prevention of lingual nerve damage associated with third molar surgery: a systematic review of the literature

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Abstract

Objective: Lingual nerve damage sometimes occurs after the removal of third molars. The use of a lingual retractor has been advocated to protect the lingual nerve. A systematic review of the literature was undertaken to evaluate the incidence of lingual nerve damage after third molar surgery and the effect of a lingual retractor on nerve damage.

Study design: An exhaustive computerized search of several databases and references cited in the various studies was performed. Predetermined inclusion and exclusion criteria were used to identify the 8 published studies acceptable for detailed analysis. The incidence and spontaneous recovery of lingual nerve injury for the following 3 surgical techniques were evaluated: the buccal approach with lingual flap retraction (BA+), or the buccal approach without lingual flap retraction (BA-), and the lingual split technique with lingual flap retraction (LS).

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Views and Perspectives

Lingual Nerve Injury

Steven B. Graff-Radford, DDS; Randolph W. Evans, MD

Lingual nerve injury is a common complication following dental and medical procedures. The clinical presentation of lingual nerve injury, its epidemiology, predisposing factors, and anatomy are explored in an attempt to identify those patients at risk for developing neuropathic pain. Nonsurgical and surgical therapies also are discussed.

Key words: lingual nerve, neuropathic pain, third molar removal

(*Headache* 2003;43:975-983)

CASE HISTORY

Three years ago, a 24-year-old woman underwent local anesthetic blocks and removal of upper and lower molars by her dentist. She subsequently reported numbness and tingling of the left side of her tongue and the floor of her mouth that have persisted up to the present time. About 3 or 4 times per week, she experiences "aching and throbbing" in the same distribution, reduced but not relieved by naproxen. She also has had disturbance of taste since the procedure; she does not like the flavor of any type of meat and has become a vegetarian. Findings from the neurologic examination are normal, except for decreased pinprick sensation over the anterior two thirds of the left side of her tongue and the floor of her mouth. Three oral surgeons have seen her, all of whom recommended nonsurgical treatment.

INTRODUCTION

Lingual nerve injury causing numbness, dysesthesia, paresthesia, and dysgeusia may complicate invasive dental and surgical therapies.[1] Lingual neuropathy also may be precipitated by infection and various metabolic, toxic, or systemic disorders. The lingual nerve is a branch of the third division of the trigeminal nerve. Although injury to the first or second trigeminal divisions may occur, this is less common (with the exception of herpes zoster, which typically affects the first division). The increased risk for surgical injury to the mandibular division may relate to anatomical issues. Trigeminal nerve injuries have been reported following tooth removal, tumor removal, osteotomy, distal wedge techniques, implant placement, and general dental therapies such as nerve block, crown preparation, and endodontic procedures.[2-7] Laryngoscopy, intubation, tongue manipulation, chemotherapy, radiation, and ischemic events may cause injury, also.[8-12] While all nerves respond similarly to injury, there may be genetic, hormonal, anatomical, physiologic, behavioral, or other factors that influence recovery.[13]

CLASSIFICATION

In 1943, Seddon classified nerve injury as: (1) neuropraxia—conduction block resulting from mild trauma, without axonal damage, and with resolution of sensory deficit within days to months; (2) axonotmesis—more severe injury, with preservation of the nerve sheath but afferent fiber degeneration, and incomplete sensory recovery; neuroma formation may occur, and the typical clinical presentation involves severe dysesthesia; (3) neurotmesis—most severe injury, with nerve severance and anesthesia in the nerve distribution, and no sensory recovery (especially if the nerve course is in soft tissue; if the nerve course is in bone, regeneration may occur).[14]

In 1951, Sunderland classified nerve injury based on the degree of tissue injury.[15] Under his system,

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Lingual nerve injury after third molar removal: Unilateral atrophy of fungiform papillae

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Abstract

Background: Pain and sensory changes due to lingual nerve injury are one of the most common alterations that follow surgical removal of third molar. They are usually transient but other less common complications, such as the atrophy of fungiform papillae, have an uncertain prognosis.
Case Description: We report a case of a 34-year-old woman who presented a unilateral lingual atrophy of fungiform papillae after third molar extraction accompanied by severe dysesthesia that altered her daily life significantly during the following months and how this complication evolved over time. We conducted a literature review on the different factors that can lead to a lingual nerve injury.
Clinical Implications: The clinical evolution of temporary and permanent somatosensitve injuries is an important fact to take into consideration during the postoperative management because it will indicate the lesion prognosis.

Key words: *Lingual nerve, third molar removal, somatosensitive alteration, papillae atrophy, permanent injury, temporary injury.*

Introduction

The surgical removal of the third molar, semi-erupted or included, is the most common dental procedure associated with lingual nerve injury (1). This lesion may involve temporary or permanent lingual sensory disturbances (anesthesia, paresthesia and/or dysesthesia) (2), sometimes accompanied by taste alterations in the anterior two thirds of the tongue causing problems like inability to chew properly or tongue biting (3). The incidence of temporary deficit is between 0-23% and permanent 0-8% (Table 1), compared with temporary (0.4 to 8.4%) and permanent (<1%) lesion of the inferior alveolar nerve (4,5,6).
The lingual nerve, a branch of the mandibular nerve, provides somatosensory innervation of the lingual mucosa through its wide range of mechanosensitive, nociceptive and thermosensitives afferent fibers. Jointly with the chorda tympani nerve fibers, a branch of the facial

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Retrospective review of microsurgical repair of 222 lingual nerve injuries

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Abstract

Purpose: Injury to the lingual nerve (LN) is a known complication associated with several oral and maxillofacial surgical procedures. We have reviewed the demographics, timing, and outcome of microsurgical repair of the LN.

Materials and methods: A retrospective chart review was completed of all patients who had undergone microsurgical repair of the LN by one of us (R.A.M.) from March 1986 through December 2005. A physical examination, including standardized neurosensory testing, was completed of each patient preoperatively. All patients were followed up periodically after surgery for at least 1 year, with neurosensory testing repeated at each visit. Sensory recovery was determined from the patient's final neurosensory testing results and evaluated using the guidelines established by the Medical Research Council Scale. The following data were collected and analyzed: patient age, gender, nerve injury etiology, chief sensory complaint (numbness or pain, or both), interval from injury to surgical intervention, intraoperative findings, surgical procedure, and neurosensory status at the final evaluation. The patients were classified according to whether they

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recovery" or better, according to the Medical Research Council Scale, or

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Management and prevention of third molar surgery-related trigeminal nerve injury: time for a rethink

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Abstract

Trigeminal nerve injury as a consequence of lower third molar surgery is a notorious complication and may affect the patient in long term. Inferior alveolar nerve (IAN) and lingual nerve (LN) injury result in different degree of neurosensory deficit and also other neurological symptoms. The long term effects may include persistent sensory loss, chronic pain and depression. It is crucial to understand the pathophysiology of the nerve injury from lower third molar surgery. Surgery remains the most promising treatment in moderate-to-severe nerve injuries. There are limitations in the current