Review Article

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Human Lingual Musculature: An Historical Review

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Introduction

The human tongue is an organ which participates in the diverse functions of prehension, gustation, mastication, deglutition, and the articulation of speech. Recently, attention has been directed to the role of the tongue in the contouring of dental arches and the positioning of teeth. A number of investigators have attempted to explain tongue function on the basis of its structure recognizing that it is the vast muscular nature of the tongue which permits its considerable flexibility, mobility and strength, and gives it the capacity for marked contractibility and rapidity of motion. Whereas the movements of the extrinsic muscles of the tongue can be inferred because of their bony attachments, inferences about the movements of the intrinsic muscles remains speculative.

While many descriptions of lingual musculature appear in the literature, most are found in texts of anatomy, and many have been based on observations of subhuman animals. Few researchers have investigated rigorously the morphology of human lingual musculature. Of the human study reports available for this review, few have systematically controlled for, or reported procedures and materials, sample size, age, sex and race of specimens, anatomic variability, and validity or reliability. Further study of human lingual musculature is needed in order to determine the morphology and anatomic variability of the muscles and their interrelationships.

This review of literature will attempt to present, in chronological sequence, the observations of human lingual musculature which have been introduced into the literature. Because the available literature is scant, the findings of each investigator will be described separately, in terms of the research methodology and materials utilized (where reported), the muscles observed, and the descriptions of muscles presented.

177 A.D. to 1777

The ancients regarded the tongue as a single muscle, the structure of which they did not attempt to unravel. Columbus [probably Realdus Columbo, 1494-1559], was the first to consider this organ as composed of two juxtaposed muscles. (Cruveilhier, 1844; p. 336)

Investigations of lingual musculature have been reported since the second century when Galen (177A.D.) described observations made during dissections of the Barbary Ape.

thought to be similar to man. Without the benefit of anatomical nomenclature, Galen described the lingual musculature with sufficient accuracy that each muscle was identifiable by its stated origin and course, or insertion.

Galen believed that muscles could only originate from bone or "firmly fixed static substances", and so never considered that the tongue was composed of more than extrinsic muscles and their coverings. He described four extrinsic muscles. *M. mylohyoideus* was described as "the bipartite, transversally directed muscle" which originated at the medial process of the hyoid bone and coursed to the chin. He described *m. hyoglossus* as the "obliquely directed muscle" which originated from the greater horn of the hyoid bone. Another muscle, *m. styloglossus*, was said to originate at the awl or needle-shaped process of the cranial bone [*p. styloideus*], pass outward from the fauces, and course to join the tongue. The fourth muscle was described as longitudinally extended along the length of the tongue. This muscle, *m. genioglossus*, was said to share a common attachment with *m. mylohyoideus*, at the midline of the entire tongue [the median mylohyoid raphe]. Galen made slight reference to *m. genioglossus*, by reporting that it lay medial to the *m. genioglossus*. However, he did not describe its origin, course or insertion.

Adreas Vesalius (1543) performing human dissections observed both extrinsic and intrinsic muscles of the tongue. He and Galen (177A.D.) were in agreement as to the origins of the *musculi hyoglossus* and *styloglossus*. However, Vesalius traced both *m. hyoglossus* and *m. styloglossus* to the root of the tongue. He concluded that *m. hyoglossus* acted to lateralize the tongue, and that *m. styloglossus*, when contracted bilaterally, drew the tongue upward.

Vesalius observed that *m. mylohyoideus* originated from the sides of the mandible near the roots of the molar teeth, but concurred with Galen (177A.D.) that it inserted along the ventral length of the tongue. *M. genioglossus*, described as thick and having furrows, was observed to originate at the inner surface of the mandible at the symphysis, and to insert in the lower part of the tongue. Vesalius stated that before dissection, *m. genioglossus* was

... interlaced with fibers of such a sort that by the great workings of Nature the tongue was very readily carried in every direction of movement. (p. 17)

The "fibers" reported by Vesalius were thought to be fibers of the *musculi transversus* and *verticalis linguae*, and the *longitudinalis superior* and *inferior*.

For three hundred years, following Vesalius, texts of anatomy abounded with simple, direct statements as to the origins and insertions of the muscles of the tongue. However, as Drake (1727) noted, authors were not in agreement about the number of muscles which composed the tongue and the perplexity of accounts was more confused than numerous. Some authors combined the muscles of the hyoid bone with those of the tongue and derived from eight to ten pairs. A few authors maintained that the tongue was composed of a single fixed pair, while others observed five, four, or only three distinct pairs of muscles.

In his account, Drake (1727) attempted to summarize selectively the descriptions of his contemporaries. Five muscles, named for their origins and insertions, were discussed. His descriptions of the "*genioglossum*" and "*styloglossum*" were not substantially different from those written by Vesalius in 1543. However, Drake felt that information on the "*myloglossum*" was not worthy of mention. In his opinion, that muscle had been obscurely described and he believed the descriptions stood on slender authority. He did describe the *musculi "ceratoglossum"* and "*chondroglossum*". He wrote that *ceratoglossum* had a broad fleshy origination at the supero-lateral part of the hyoid bone, from which it

ascended to insert into the root of the tongue. Quoting Verheyer, Drake described chondroglossus as a short narrow pair arising from the cartilaginous process of the hyoid bone. Its fibers were said to meet, insert and form an arch in the middle of the base of the tongue.

Hunter, writing in 1752, combined the muscles of the hyoid bone and tongue in a single section of his lectures on anatomy. In his description of *m. styloglossus* he specified that the muscle coursed the entire length of the tongue but did not mention its insertion into the root of the tongue. He described *m. hyoglossus* as rising from the base and cornu of the hyoid bone, and running laterally and forward. He noted that some authors had divided *m. hyoglossus* into three parts and called them *basioglossus*, *chondroglossus* and *ceratoglossus*. In addition, Hunter noted fibers, the "lingualis" which he stated were previously described by Albinus and Douglas. The lingualis was said to arise from the fleshy fibers and become lost in those fibers in their course from the base to the apex of the tongue. The fleshy fibers, wrote Hunter, were "... under the papilla on the surface of the tongue. ... running in all possible directions" (p. 110).

Douglas (1777), referring to the lingualis in greater detail than Hunter, seemed to describe fibers which are at present referred to as the *m. longitudinalis inferior*. Douglas wrote that these fibers originated large and fleshy from the base of the tongue laterally, and coursed straight forward between the *musculi ceratoglossus* and *genioglossus*, to the tip where its terminal course was difficult to determine.

The other muscles of the tongue described by Douglas, in addition to the lingualis, were the *musculi "genio-glossus, cerato-glossus and stylo-glossus"*. *M. styloglossus* was said to arise as a tendinous and fleshy bundle from the *processus styloformis* [*p. styloideus*] of the temporal bone, and often also from a fleshy ligament that extended from that process to the angle of the lower jaw. Douglas' description of *m. styloglossus*' insertion into the side of the tongue from its root to near its middle, was similar to the earlier descriptions of Vesalius (1543) and Drake (1727). In the most detailed description of *m. genioglossus* up to that time, Douglas noted that the muscle arose tendinous from a rough protuberance inside the middle of the chin. He described its fibers as coursing in three directions: the anterior fibers toward the tip, middlemost fibers to the middle of the tongue, and the posterior fibers obliquely backward toward the root of the tongue and horns of the hyoid bone. Fibers of the *ceratoglossus* muscle were said to arise as a fleshy bundle from three sources: the first from the cornu of the hyoid bone (properly called *ceratoglossus*), the second from the basis of the hyoid bone (*basioglossus*), and the third from the cartilaginous appendages of the hyoid bone (*chondroglossus*). Fibers from these three sources were said to unite and course in the same direction. Their insertion was not described.

By the end of the eighteenth century, a number of investigators had described the muscles of the tongue. Opinions differed as to which muscle composed the tongue, so that the number of muscles described varied from one report to another. Galen (177A.D.) and Vesalius (1543), described muscles of the tongue and hyoid bone as a single complex of muscles. Drake (1727), Hunter (1752) and Douglas (1777) alluded to intrinsic muscle fibers, but, for the most part, extrinsic fibers were considered muscles of the tongue. Only the most superficial muscular interrelationships were described. *M. genioglossus* was described by three investigators (Vesalius, 1543; Drake, 1727, Douglas, 1777). The *musculi styloglossus* and *hyoglossus* were described in all of the works reviewed. However, Galen (177A.D.) and Vesalius (1543) described *m. hyoglossus* as a single muscle, Hunter (1752) and Douglas (1777) described it as a single muscle divided into three parts, and

Drake (1727) described it as three separate muscles. The discrepancy over the division of *m. hyoglossus* contributed to the confusion about the number of muscles which properly composed the tongue. This discrepancy was to persist for some years to follow.

1777 to 1852

Extensive descriptions of human tongue musculature appeared in the literature of the nineteenth century. Of the four reports discussed below, all provided information about the source, but none provided information about the number of specimens observed or the validity of observations. Only one (Soemmering, 1841) discussed the variability of the muscles observed.

While his article was not translated from the original French, it was apparent that Blandin (1823) reviewed the observations of previous investigators. He observed transverse, longitudinal and perpendicular intrinsic as well as extrinsic muscles during the dissection of both sub-human and human specimens.

After examining an undetermined number of fresh human tongues, Soemmering (1841) observed the attachments, course, variability and function of both intrinsic and extrinsic tongue muscles. *M. genioglossus* was described as the "finest" muscle of the tongue, spreading itself in its entirety into halves of the tongue in a vertical direction. This muscle was said to originate from a "sinewy streak" [possibly tendon] and the "under jaw" on either side of the streak. Its inferior fibers were described as passing exactly linearly to the hyoid bone where they spread in a crosswise [probably transverse] direction above that bone. More superior fibers of the muscle were said to pass under the tongue to its root, while remaining fibers, composing the largest part of the muscle, penetrated vertically between the midline and lateral borders of the tongue. These last fibers were interdigitated by fibers of the *m. transversus linguae* but coursed vertically to the plane of the *m. longitudinalis superior*. The most anterior portion of these fibers were reported to reach the tongue tip.

Soemmering described *m. hyoglossus*, which he also referred to as "basioceratohondroglossus", as a thin, four-sided flat muscle with some fibers springing in a row along the length of the entire greater horn of the hyoid bone, and others springing from the middle of the hyoid bone. He does not, like Douglas (1777) and others, describe fibers from the cartilaginous portion of the hyoid bone. All of the fibers of *m. hyoglossus* observed by Soemmering were said to pass obliquely above and forward to reach the lateral part of the tongue. He observed that the anterior fibers were approximately two inches long and that the posterior fibers were approximately one inch long before they disappeared into the substance of the tongue just inferior to *m. longitudinalis superior*. Having penetrated the lingual mucosa, the anterior fibers were observed to course to the tip with the musculi *styloglossus* and *longitudinalis inferior*.

Soemmering described the *p. styloideus* and *I. stylomaxillare* as points of origin for *m. styloglossus*, and noted that the muscle coursed anteriorly to the ventral aspect of the tongue tip with the musculi *hyoglossus* and *longitudinalis inferior*, and medially after penetrating *m. hyoglossus*. The latter fibers of *m. styloglossus* were said to find fibers of the cross muscles [*m. transversus linguae*] of the tongue.

Based on examinations of the fresh tongue of a sixteen year old boy, Soemmering determined that three intrinsic muscles existed: the musculi *longitudinalis superior* and *inferior*, and the *m. transversus linguae*. Under the fatty mucous membrane of the tongue, he found a layer of longitudinal fibers [*m. longitudinalis superior*] which originated from the tongue root between the gland layer and the hyoid bone and passed with intermittent

terminations and new origins to the tongue tip. He found, between the muscoli genioglossus and hyoglossus, a spindle-shaped rope of muscle [m. longitudinalis inferior] which passed from the root to the tip of the tongue. This muscle was said to unite anteriorly with fibers of the muscoli hyoglossus and styloglossus. Finally, he observed the m. transversus linguae and reported that it sprang in two halves from the median septum. Layers of this muscle were observed to be thicker infero-superiorly in the posterior aspect of the tongue than in the anterior aspect. The most superior layer was reportedly short antero-medially, while the more inferior layers were increasingly longer and coursed in a convex manner to the sides of the tongue. Soemmering was not able to distinguish intrinsic vertical fibers from the vertical fibers of the m. genioglossus.

Cruveilhier (1844) utilized coronal and sagittal sections of boiled human (and other) tongues to demonstrate the existence of longitudinal, transverse, and vertical intrinsic fibers. His description of the m. longitudinalis inferior was similar to those of Douglas (1777) and Soemmering (1841). However, Cruveilhier noted that the anterior fibers of the muscle converged with fibers of the muscoli styloglossus and genioglossus. Like Soemmering (1841), Cruveilhier found that fibers of m. longitudinalis superior arose in succession, but from the "papillary membrane". He reported, as did Soemmering (1841) that layers of the muscle were thicker in front, where the fibers were compressed into the tip, than behind, where they were scattered.

Of interest, were two oblique and very thin layers of fibers which Cruveilhier (1844) observed on either side of the tongue. The superficial layer consisted of fibers passing forward and downward, while the deep layer of fibers passed obliquely forward and upward. These fibers, he stated, were only seen toward the base of the tongue. In addition, along each side of the tongue, he found some antero-posterior fibers which he described as continuous with both the muscoli stylo-glossus and palatoglossus.

Cruveilhier did not believe, as did Soemmering (1841) that the median lingual septum was the point of origin for the m. transversus linguae. Instead, he reported that this muscle extended in a slight concavity, from one side of the tongue to the other. Like Blandin (1823), he observed vertical fibers (m. verticalis linguae) which coursed from the upper to the lower surfaces of the tongue, converging slightly from above, downward.

Cruveilhier noted the muscoli styloglossus, hyoglossus, and genioglossus as extrinsic muscles. His descriptions of these muscles, though more detailed, were similar to those of previous investigators cited in this review. Blandin (1823), Soemmering (1841), and Cruveilhier (1844) all noted that m. styloglossus was attached to both the p. styloideus and the l. stylomaxillare, at its origin. Cruveilhier elaborated on these earlier descriptions by reporting that m. styloglossus passed downward, inward, and forward from these points of origin, and states that

... at the margin of the tongue, opposite the anterior pillar of fauces, the muscle became flattened, expanded and triangular, and divided into two parts: one external, which runs along the corresponding margin of the tongue, from base to apex; the other internal, which passes between the two portions of the hyoglossus, assumes a transverse direction, and is blended with the transverse fibers of the tongue. (p. 337-8)

Cruveilhier described the two points of origin for m. hyoglossus and the quadrilateral shape of that muscle exactly as Soemmering (1841) did, but stated further that the muscle terminated in the sides of the tongue between the muscoli styloglossus and the lingualis [m. longitudinalis inferior]. He also observed continuity between fibers of m. hyoglossus and the vertical fasciculi of the tongue. He referred to m. genioglossus as "genio-

hyoglossus", indicating the various attachments of the fibers. The origin of the muscle was described as "the superior genial process of the inferior maxilla" [the mandibular symphysis]. From this origin, some fibers of the muscle were reported to course posteriorly to attach to the hyoid bone, forming the "superior genio-hyoideus of Ferrein". This attachment was also noted by Douglas (1777) and Soemmering (1841). The latter also made reference to the "superior geniohyoideus". Like Soemmering (1841), Cruveilhier reported that more anterior fibers of m. genioglossus coursed to the sides of the pharynx between the hyoid bone and m. styloglossus, but specified that these fibers constituted the "geniopharyngiens of Winslow". The other anterior fibers of m. genioglossus were observed by Cruveilhier to traverse the length of the tongue and terminate near its tip. The most anterior fibers were observed to course vertically upward and a little laterally to terminate in the mucous membrane lateral to the medial septum of the tongue.

In the *Todd Cyclopaedia of Anatomy and Physiology*, Salter (1852) described human and comparative anatomy of the tongue. His extensive descriptions of the human tongue were based on gross dissection, observations of cut tongue surfaces, and microscopic examination of thin coronal and sagittal sections. From these procedures Salter classified muscles of the tongue as

. . . intrinsic. . . those which form the substance of the organ, that pass from part to part of it, and that move the tongue on itself. . . extrinsic (proper) . . . those that, as well as entering. . . the substances of the tongue, pass from it to neighboring fixed points, to which they attach it, and on which they move it. . . accessory. . . though not contributing in any degree to the formation of the tongue, nor attach to it, are. . . acting as coadjutors to those proper extrinsic muscles whose direction coincides with theirs. . . (p. 1125)

Salter observed two portions of m. verticalis linguae: one portion was intrinsic, and the other was the lingual portion of m. genioglossus. He noted that m. longitudinalis superior originated from the hyoglossal membrane and cutis at the base of the tongue and that it had a similar cutaneous insertion on the upper surface of the tip and neighboring parts of the tongue. He corroborated reports by Cruveilhier (1844) and Soemmering (1841) on the origin of m. longitudinalis inferior, but felt he could not accept Cruveilhier's (1844) observation that the m. longitudinalis inferior terminated between the muscoli styloglossus and genioglossus; he felt that the anterior fibers of m. genioglossus did not bend forward sufficiently to become longitudinal. His observations of the attachments and course of the m. transversus linguae were not substantially different from those of Cruveilhier (1844); nor were his observations of fibers which he called "lateral lingual". However, Salter believed that the latter fibers were derived from the muscoli styloglossus and hyoglossus, and Cruveilhier (1844) believed that they were derived from the muscoli styloglossus and palatoglossus. Salter reported that, as they passed anteriorly, the fibers from the muscoli styloglossus and hyoglossus became fused and spread to constitute a thin layer.

Salter's most valuable contribution to the literature was his exposition of the architectural interrelationships and mode of termination of the intrinsic muscles. Examining coronal sections of the most posterior part of the free portion of the tongue, he found three sets of fibers crossing at right angles, one to the other. Vertical and transverse fibers interdigitated and entirely occupied the center of the tongue, excluding the longitudinal fibers. At the superior, inferior and lateral borders of the tongue, the vertical and transverse fibers emerged from this pattern fanned out and coursed in almost parallel bundles to the mucous membrane. Between those parallel bundles he found bundles of longitudinal fibers.

Regarding the termination of the muscles, Salter found that . . . all the intrinsic fibers of the tongue, and indeed, . . . almost if not all of the extrinsics too, terminate by becoming inserted in the cutis—the submucous fibrous tissue. . . Each fiber, before termination, gradually tapered, in a fusiform manner. . . nearly as fine as the fibrous tissue in which it terminates. . . (p. 1132)

Salter included *m. palatoglossus* (also referred to as “glosso-staphlinus”), among those he described as extrinsic muscles of the tongue. He observed that *m. palatoglossus* originated in the soft palate and descended forming the anterior pillar of fauces to insert into the side of the tongue. There it mingled with fibers of *m. styloglossus*, and then passed transversely into the medullary structure of the tongue. With few exceptions, Salter’s descriptions of the *musculi styloglossus*, *hyoglossus*, and *genioglossus* were no different from those of Cruveilhier (1844). However, contrary to Cruveilhier (1844), Salter found the direction of *m. genioglossus* fibers to be upward and inward throughout the tongue. In addition he found no disposition to lateral divergence in any aspect of the muscle course, and his “genio-pharyngiens of Winslow” was formed by posterior fibers of *m. genioglossus* uniting with the *m. constrictor pharyngis medius*. Salter provided further information about *m. genioglossus*, stating that after entering the tongue it passed to the cutis of the dorsum to form part of the vertical intrinsic muscle.

Blandin (1823), Soemmering (1841), Cruveilhier (1844), and Salter (1852) writing during the first half of the nineteenth century, all agreed that the tongue was composed of both extrinsic and intrinsic muscle fibers. All described the *musculi styloglossus*, *hyoglossus*, and *genio-glossus* as the extrinsic muscles. Salter also included *m. palatoglossus*. With one exception, all described the *musculi transversus linguae*, *verticalis linguae*, *longitudinalis superior*, and *longitudinalis inferior*, as the intrinsic muscles. Soemmering (1841) was not able to distinguish intrinsic vertical fibers. During that period, techniques of histological staining and sectioning were introduced which enabled investigators to describe in greater detail the origin, course, insertion, mode of termination and fundamental interrelationships of the lingual muscles. These procedures set a precedent for all subsequent research.

1852 to 1975

During the twentieth century, numerous articles were written on aspects of lingual embryology, development and morphology. However, only two of those articles (Abd-El-Malek, 1939; Miyawaki, 1973) presented empirical descriptions of the musculature. Although neither author specified intrinsic versus extrinsic muscles, each described the intrinsic and extrinsic muscles observed by previous investigators. In addition, the methodologies, form, and content of descriptions in these studies were similar to those utilized and presented by Soemmering (1841), Cruveilhier (1844) and Salter (1852).

The article most commonly cited in the literature on the human tongue was written in 1939 by Abd-El-Malek. His detailed descriptions of the morphology of the human tongue were based on observations of magnified celloidin transverse serial sections. Unfortunately, Abd-El-Malek did not report the number, sex or age of his specimen(s), or the validity or variability of his observations. No references were cited. However, it was interesting to note the similarities between his observations and those of Cruveilhier (1844) and Salter (1852) made nearly a hundred years earlier.

Abd-El-Malek described the points of origin of *m. styloglossus* as the anterior and lateral surfaces near the apex of the *p. styloideus* and the proximal part of the *I. stylomandibulare*. Douglas, (1777), Blandin (1823), Soemmering (1841), Cruveilhier (1844) and Salter (1852) had all noted this double origin but from the process and *I.*

stylomaxillare. Abd-El-Malek, in agreement with Cruveilhier (1844) and Salter (1852), described the division of the muscle into two parts. While Cruveilhier (1844) noted internal and external portions of the muscle, Abd-El-Malek noted an upper portion which coursed toward the tip and a lower portion which decussated superficially with the lateral surface of *m. hyoglossus*. Like Salter (1852), he observed that as *m. styloglossus* coursed anteriorly along the lateral margin of the tongue it blended with fibers of the *musculi hyoglossus* and *longitudinalis inferior*. Abd-El-Malek also observed fibers of *m. genioglossus* among the anterior group, and noted that the fibers of all four muscles (*styloglossus*, *hyoglossus*, *genioglossus* and *longitudinalis inferior*) inserted into the anterior arch.¹

Abd-El-Malek's description of *m. hyoglossus* paralleled those of Cruveilhier (1844) and Salter (1852). Each described the double origin of the muscle at the body and greater cornu of the hyoid bone. However, while Salter (1852) described two sets of fibers with two distinct courses, Cruveilhier (1844) described one general course of fibers and Abd-El-Malek described several. The latter wrote that the anterior fibers coursed nearly longitudinally to insert into the tip. The posterior fibers, decussated with *m. styloglossus*, and radiated transversely and posteriorly to insert into the tongue root. Middle fibers were reported to course medially and dorsally, and differed in obliquity from the anterior and posterior fibers. In addition, Abd-El-Malek described the insertion of some of the posterior and middle fibers into the paramedian septum and the mingling of the remaining fibers with *m. longitudinalis superior* dorsally, and with the *musculi transversus linguae* and *genioglossus* ventrally.

Cruveilhier (1844), Salter (1852) and Abd-El-Malek (1939) agreed that *m. genioglossus* was the largest lingual muscle they observed. Each described fibers which radiated antero-posteriorly from their origin at the symphysis menti of the mandible. However, Abd-El-Malek made no mention of fibers reaching the pharynx to form the *genio-pharyngiens* of Winslow. He agreed with Cruveilhier (1844) that fibers of *m. genioglossus* radiated in an outward or lateral direction. Each of the investigators reported the insertion of fibers into the mucous membrane of the tongue. However, only Abd-El-Malek noted that a number of fibers, after penetrating *m. longitudinalis superior*, decussated with the corresponding fibers of the opposite *m. genioglossus* before attaching to the *lamina propria*.

The *musculi longitudinalis superior* and *inferior* were described most extensively by Abd-El-Malek. He found, contrary to Cruveilhier (1844) and Salter (1852), that *m. longitudinalis superior* was a bulky mass, triangular in cross-section. Its posterior fibers appeared thin, attaching partly to the lower and ventral part of the epiglottis and the *l. hyo-epiglotticus* and partly to the *hyoglossal* membrane. Its anterior fibers were observed to flatten and attach partly to the dorsal *lamina propria* and partly to the dorsal part of the anterior arch. Abd-El-Malek reported that the lateral fibers of the muscle joined the longitudinal fibers of the *musculi styloglossus*, *hyoglossus*, and *longitudinalis inferior* at the lateral border of the tongue.

Abd-El-Malek described two points of origin for *m. longitudinalis inferior*; a lateral attachment from the lateral aspect of the body of the hyoid bone and root of its greater cornu, and a medial attachment in conjunction with lateral and ventral fibers of *m. genioglossus*. Although Cruveilhier (1844) and Salter (1852) both observed a posterior

¹The anterior arch was described by Abd-El-Malek as the condensed, cap-like portion of the *lamina propria* at the tip of the tongue.

attachment and described the sandwich-like appearance of the muscoli hyoglossus, longitudinalis inferior, and genioglossus, neither seemed to have observed origin at the hyoid bone or the attachment of a few fibers to the l. stylohyoid, described by Abd-El-Malek. All agreed that anterior fibers of m. longitudinalis inferior were joined with fibers of m. styloglossus. Abd-El-Malek added that they were also joined with muscoli hyoglossus and genioglossus, before terminating in the anterior arch.

Although Salter (1852) detailed the arrangement of transverse and vertical fibers in the tongue, his description of the morphology of the muscles was not as extensive as that of Abd-El-Malek. The latter described m. transversus linguae as situated between the muscoli longitudinalis superior dorsally, and genioglossus and longitudinalis inferior ventrally. Abd-El-Malek supported the earlier observations of Soemmering (1841) that the m. transversus linguae extended laterally from the median septum. Two types of transverse fibers were observed by Abd-El-Malek. The long fibers were reported to reach the lamina propria at the sides of the tongue, while the short fibers were reported to reach the septa of neighboring muscles.

Like Salter (1852), Abd-El-Malek found that fibers of the m. verticalis linguae, in combination with the m. transversus linguae, formed a considerable portion of the center of the tongue. The two investigators agreed that fibers of the m. verticalis linguae reached the dorsal lamina propria and the ventral submucous layer. However, Abd-El-Malek also found that some of its fibers extended only to adjacent muscle septa.

The most recent description of human lingual musculature appeared in 1973. Using 2.5 to 3 millimeter transparent serial sections of three adult tongues, and assisted by dissections of two adult tongues, Miyawaki (1973) made observations and drawings of the musculature in three planes of section. Although his descriptions revealed little more than had previously been described, his drawings of the serial sections observed were valuable in their illustration of the muscular interrelationships. Unfortunately, he gave no indication of the degree of variability observed among the five specimens, or of the bilateral variability within specimens. The sex, race and ages of the specimens were not provided.

Miyawaki observed the attachment of m. styloglossus to the p. styloideus only. He noted that once the muscle had inserted into the sides of the tongue mass three portions became apparent. His anterior fibers coursed with m. longitudinalis inferior toward the tip. His middle fibers, flat supero-inferiorly, lay inferior to m. longitudinalis inferior while his posterior fibers, flat medio-laterally, lay lateral to m. hyoglossus. Miyawaki, apparently did not observe the medial course of fibers described by Soemmering (1841), Cruveilhier (1844), Salter (1852) and Abd-El-Malek (1939).

With one exception, Miyawaki's description of m. genioglossus coincided with those of other authors reviewed in this paper. He wrote

... fibers of genioglossus are not found to curve anteriorly as is often shown in the text books of anatomy and are not found in the tip of the tongue. (p. 27)

Miyawaki observed and illustrated longitudinal fibers that were continuous from the root to the tip of the tongue. These fibers of m. longitudinalis superior lay just inferior to the dorsal lamina propria. This finding differed from those of Soemmering (1841) and Cruveilhier (1844), both of whom found that as the muscle progressed toward the tip, short fibers inserted into and originated from the dorsal lamina propria. Miyawaki mentioned no region or point of insertion for his m. longitudinalis superior.

The descriptions of the muscoli longitudinalis inferior and transversus linguae presented by Miyawaki were sufficiently similar to those of Abd-El-Malek (1939), Salter

(1852), and Cruveilheir (1844) that they need not be recounted here. However, Miyawaki's observations of *m. verticalis linguae* should be noted. He wrote of the *m. verticalis linguae*, ". . . this muscle is only found in the superior half of the tongue. . ." (p. 29), and observed that the fibers, for the most part, interdigitated with fibers of *m. longitudinalis inferior*, where they terminated before reaching the inferior surface of the tongue. The observations of Abd-El-Malek (1939) and Salter (1852) differed from those of Miyawaki. They found that fibers of *m. verticalis linguae* coursed dorsally to the lamina propria as well as ventrally to the submucous layer.

In general, the studies of Abd-El-Malek (1939) and Miyawaki (1973) tended to support the work of earlier investigators. Abd-El-Malek described the interrelationships of the musculature in more detail than did previous investigators with the possible exception of Salter (1852), and discussed the attachment of muscles to septa within the tongue. Miyawaki's (1973) observations were described primarily by means of his drawings, which were valuable because they illustrated the interrelationships of the muscles of the tongue. However, his written descriptions, which only served to guide the reader through his series of illustrations, contributed little to the literature.

Summary

A thorough review of the available literature on the musculature of the human tongue has revealed areas of agreement and disagreement as well as, areas which have not been investigated at all. Anatomical descriptions of lingual musculature have largely been directed toward the identification of origins, readily apparent courses, and regions of insertions for the muscles. Only two of the reports have described the muscles by stratum; one through empirical descriptions of muscles seen in histological sections (Salter, 1852), and the other, through a series of illustrations (Miyawaki, 1973). No reports of direct measurements, that is, fiber counts or measurements of cross sectional area, were found.

With respect to the areas of disagreement found, it is possible that the variable descriptions of the muscles are indicative of true anatomic variability among the specimens observed. Differences in observations may also be related in differences in the procedures employed to obtain the data. Gross dissection, observation of cut tongue sections and microscopic examination of histological sections of varying thickness and in various planes, was employed.

Finally, it was apparent from the literature reviewed, that each of the muscles of the tongue are in need of further, well defined, empirical description. Studies are needed on the developmental morphology of the human tongue. None appear in the literature. Although anatomically, the muscles are described individually, it should be remembered that it is only through their combined actions that the organ is able to participate in complex functions such as the articulation of speech. Therefore, the morphology and physiology of muscular interrelationships, as well as lingual innervation for gross versus fine movements and proprioception are important areas which remain to be investigated.

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