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The Morphology Of Musculus Styloglossus In Fifteen-Week Human Fetuses

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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 possible role of the tongue in the contouring of dental arches, and the positioning of the teeth, and its possible tendency to be influenced behaviorly by the architecture of the oral cavity. 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 are considerably more difficult to draw.

Many descriptions of lingual musculature appear in the literature, as reviewed by Barnwell (1976) and Dickson, et al. (1975), but 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. 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, such as fiber counts or measurements of cross sectional areas, were found.

Whereas, the direction of intrinsic muscle fibers has been well defined, there is little agreement as to the origins and insertions of these muscles. There is still a question as to whether or not intrinsic muscles, particularly the musculus verticalis linguae, exist. It is precisely because the intrinsic muscles do not have extrinsic points of attachment that it is so difficult to isolate and trace these fibers from origin to insertion. Therefore, as a primary step in the further investigation of lingual musculature, the fibers of the extrinsic muscles must be traced systematically from their origins to insertions so that once the morphological boundaries are established, a frame of reference will exist for the study of the intrinsic muscles.

The present study was designed to investigate the morphology of one extrinsic muscle, the musculus styloglossus; its origin(s), course, insertion(s), and interrelationships with adjacent muscles.

REVIEW OF THE LITERATURE

The origin(s) of musculus (m.) styloglossus have been well defined in the literature. Investigators are agreed that it originates at the processus (p.) styloideus. In addition, Blandin (1823), Soemmering (1841), and Cruveilhier (1844) noted a second attachment to the ligamentum (l.) stylomaxillare. Abd-El-Malek (1939) found a second attachment at the l. stylomandibulare. The "stylomaxillare" versus "stylomandibulare" discrepancy appears to be one of terminology and not of structure. The term "stylomaxillare" is not in current use and cannot be found in modern texts of anatomy. Moreover, the variability of the attachment to the ligament has not been determined.

Cruveilhier (1844), Salter (1852), and Abd-El-Malek (1939) found that m. styloglossus divides into two parts after coursing inferiorly to reach the side of the tongue. One part courses along the lateral margin of the tongue toward the tip where its fibers merge with those of m. hyoglossus (Salter, 1852; Abd-El-Malek, 1939), m. longitudinalis inferior (Salter,

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1852; Abd-El-Malek, 1939; Miyawaki, 1973), and m. genioglossus (Abd-El-Malek, 1939). The other part lies lateral to m. hyoglossus (Miyawaki, 1973), turns inward (Salter, 1852), decussates superficially with the lateral surface of m. hyoglossus (Abd-El-Malek, 1939), and/or penetrates m. hyoglossus to blend with fibers of m. transversus linguae (Cruveilhier, 1844).

Investigators agree on the course of the muscle from its point(s) of origin to the root of the tongue. In addition, they agree that fibers of the muscle course anteriorly along the lateral borders of the tongue toward the tip. However, only one investigator (Abd-El-Malek, 1939) stated conclusively that fibers were found in the tongue tip. They were reported as being attached to the anterior arch. Apparently, other investigators were not able to follow the fibers to the tip. It remains to be determined whether the anterior fibers of m. styloglossus terminate before reaching the tongue tip, can be traced directly into the tongue tip, or are obscured from view at the tip by their convergence or intermingling with fibers from adjacent muscles.

Further questions concern whether some fibers course medially into the substance of the tongue, the percentage of fibers coursing medially, the extent of the medial excursion, the interrelationship of those fibers to fibers of adjacent muscles, and their points and mode of insertion. One final question concerns whether fibers from the opposite side form a transverse sling in the base of the tongue.

Three procedures for investigating lingual morphology have been described in the literature: gross dissection (Galen, 177 A.D.; Vesalius, 1543; Drake, 1727; Douglas, 1777; Blandin, 1823; Soemmering, 1841; Salter, 1852; Miyawaki, 1973), observations of cut tongue surfaces (Cruveilhier, 1844; Salter, 1852), and the microscopic examination of thin, histologically prepared sections (Salter, 1852; Abd-El-Malek, 1939; Miyawaki, 1973). While all three procedures have yielded valuable information in the past, it was apparent from the literature that the microscopic examination of histological sections had provided the most detailed information. Therefore, the investigation of histologically prepared specimens became the method of choice of the present research.

METHODS AND MATERIALS

Fourteen, fifteen-week human fetal specimens, seven males and seven females, were selected for study. In addition, gross dissection of a single adult specimen was employed for comparison with observations from the fetal specimens.

Each of the fetal specimens had been examined and judged free of craniofacial malformations and had subsequently been embedded in paraffin for sectioning at thirty microns of thickness in one of three standard anatomical plans: transverse (Fig. 1), coronal (Fig. 2) or sagittal (Fig. 3). The sections were then stained alternately with a modified Masson trichrome stain or a modified Bodian silver nitrate nerve stain.

A preliminary investigation of three fifteen-week fetal heads, each sectioned in a different anatomical plane, suggested that m. Styloglossus could best be studied in specimens sectioned transversely. In this plane, fibers of m. styloglossus could be traced from their point(s) of origin to their medial and anterior regions of termination. In the coronal plane, fibers coursing toward the tip of the tongue could be viewed in cross-section and in the sagittal plane, the serial sections followed the same medial course as the posterior fibers of m. styloglossus.

In the present study, nine specimens sectioned in the transverse plane were examined. In order to substantiate observations of m. styloglossus in that plane, three specimens sectioned coronally and two specimens sectioned sagittally were examined.

Figure 1. The outline of a tongue viewed from the side. Transverse sections were cut in the manner indicated by horizontal parallel lines from the dorsal to ventral surface of the tongue.

Figure 2. The outline of a tongue viewed from the side. Coronal sections were cut in the manner indicated by the vertical parallel lines from the anterior to posterior surface of the tongue.

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Figure 3. The outline of a tongue viewed from the front. Sagittal sections were cut in the manner indicated by vertical lines from lateral surface to lateral surface.

Microscopic Observations

For each specimen, an average of two hundred and sixty-five serial sections displaying m. styloglossus, its attachments, and its course were examined using a low power binocular dissecting microscope and a binocular microscope. After making microscopic observations of the muscle site, the nature of its origin, the course and terminal morphology of its fibers, the sections were traced by projecting them in sequence with a photographic enlarger. The average magnification of specimens was 15X.

Composite and Representative Tracings

A composite tracing was obtained from the serial sections of each of the fourteen specimens examined microscopically. These tracings were the result of the successive addition of information from many serial sections to a single drawing. Composites for all specimens were obtained by projecting sections in sequence, by aligning pertinent structures (eg. Meckel's Cartilage) and muscle fibers, and by tracing those fibers successively from their point(s) of origin to insertion on a single sheet of paper.

Two anatomists reviewed six of the fourteen specimens examined by this investigator. When considering which fibers comprised m. styloglossus in each of those specimens, agreement was reached to a point where only occasional fibers were in question. In addition, agreement was obtained for judgments of how structures in serial sections were to be aligned in order to insure accurate tracing of muscle fibers as they appeared in successive sections. One anatomist independently traced structures in a specimen previously traced by

this investigator. When the two tracings were superimposed, no substantial differences were detected in the way structures had been aligned or in the fibers which had been traced. Representative tracings were obtained in the same manner as the composite tracings except that they consisted of individual, thirty-micron sections which were traced separately. The sections traced were selected to illustrate distinct changes in the course, position, and shape of the distinct changes in the course, position, and shape of the fiber bundles and/or changes in the relationship of the muscle to adjacent structures.

Specimen and Procedures for Gross Dissection

The specimen used in the gross dissection portion of this study was an apparently normal adult caucasian male cadaver.

A superficial to deep approach was applied to the hemisected head of the cadaver in order to facilitate the dissection of *m. styloglossus*. An incision was made inferior and parallel to the *p. zygomaticus*. This incision was then extended inferiorly along the posterior border of the ramus to the angle of the mandible. All structures superficial to the structures of interest, including the mandible, were excised. The tongue, *p. styloideus* with its musculature, and the hyoid bone were then accessible.

Using a dissecting microscope, the overlying fascia of the *mm. styloglossus* and *hyoglossus* was removed so that those fibers could be clearly visualized. *M. styloglossus* was freed from its attachment at the *p. styloideus*. In order to expose the anterior fibers of *m. styloglossus* and *m. longi tudinalis superior*, the mucosa lingua was removed from the lateral and dorsal surface of the tongue. Fibers of *m. longitudinalis superior* and surrounding fatty connective tissue were elevated so that the supero-medial fibers of *m. styloglossus* could be isolated. Layered bundles of *m. hyoglossus* were dissected out, leaving the latera fibers of *m. styloglossus* in relief so that their destination could be determined. Finally, the remaining tissues (muscular, connective, vascular, etc.) were reflected and/or removed so that *m. styloglossus* could be viewed into.

RESULTS

Average Appearance of Musculus Styloglossus In Fetal Specimens

Origins

In most of the specimens examined, *m. styloglossus* had its origin lateral and superior to the dorsal surface of the tongue mass at the *p. styloideus* and the *l. stylomandibulare*. This double origin gave the muscle the appearance of having two heads. Fibers were attached to both the process and ligament by short tendonous fibers. The styloid attachment was near or at the apex of the process and was to any or all of three surfaces: lateral, superior, and/or medial. No fibers were attached to the inferior surface of the process.

Course of the Extrinsic Portion of *M. Styloglossus*

For the purpose of this study, the extrinsic portion of *m. styloglossus* was defined as that portion of the muscle external to the tongue mass, which coursed from its point(s) of origin to the lateral borders of *m. hyoglossus* at the postero-lateral border of the tongue. The fibers of this portion, arranged in a fusiform belly, initially coursed anteriorly, medially and slightly inferiorly from their point(s) of origin. They deviated superiorly to curve obliquely around the superior surface of the glandula submandibularis. Having gained the medial surface of the gland, the fibers continued on an infero-medial course until they lay just lateral to the vertical fibers of *m. hyoglossus* at the root of the tongue. Here, the fibers of *m. styloglossus* were parallel and infero-lateral to fibers descending from the palate (*m. palatoglossus*).

Course of the Intrinsic Fiber Bundles

At the lateral borders of *m. hyoglossus*, there was a distinct bifurcation of the portion of *m. styloglossus*. An estimated 75 per cent of the fibers in that portion (those most medial and in close proximity to *m. hyoglossus*) turned antero-medially, interdigitated with discrete bundles of *m. hyoglossus*, and then turned medialward to assume a transverse direction. These fibers projected medially approximately half way to midline, closely approaching the lateral borders of *m. genioglossus* before either terminating in the connective tissue investment or becoming indistinguishable from fibers of *m. transversus linguae*. These fibers of *m. styloglossus* appeared to lie in several horizontal layers in the tongue root with the

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superior layer just inferior to fibers of the m. longitudinalis superior and the inferior layer on a plane slightly above the body of the hyoid bone.

An estimated 25 per cent of the fibers from the extrinsic portion of m. styloglossus maintained their position lateral to m. hyoglossus and just medial to the lamina propria of the tongue. Inferior to m. longitudinalis superior, in the ventral third of the tongue, these m. styloglossus fibers coursed as a thin, flat bundle along the lateral length of the tongue toward the ventral aspect of the tongue tip. The long axis of these fibers often appeared to be intersected by fibers of the m. transversus linguae. As m. styloglossus coursed forward through the anterior third of the tongue tip, its fibers merged with, were overlapped by, and became indistinguishable from the more medial fibers of the mm. hyoglossus and longitudinalis inferior and more lateral oblique fibers arising from the lamina propria (hereafter referred to as the oblique fibers). This intermingling of fibers made it difficult to trace m. styloglossus beyond that point and to determine its region and mode of termination.

Anatomical Variability of M. Styloglossus in Fetal Specimens

Two sources of variability were observed during this study: true anatomical variability considered either systematic or random, 2nd perceived variability, an artifact of the plane of section in which the muscle was examined. No apparent systematic variability was observed when m. styloglossus was compared in male and female specimens. Minimal bilateral variability was apparent in nine of twelve specimens in which m. styloglossus was traced bilaterally. No apparent bilateral variability was found in the other three specimens. When data from the fourteen specimens were examined, no apparent variability was observed in the course of m. styloglossus or its interrelationship with adjacent structures. However, variability was apparent in the site and number of points of origin, the relative length and bulk of the extrinsic portion of the muscle, the extent to which the posterior fibers penetrated to midline, and the extent to which the lateral fibers coursed anteriorly toward the tongue tip.

Variability of Muscle Origin

M. styloglossus originated at both the p. styloideus and the l. stylomandibulare in nine of twelve specimens examined in the transverse and coronal planes. In two of the twelve specimens (Figs. 5, 12), the muscle originated only at the process. In the twelfth specimen (Fig. 8), the origin was limited to the ligament. Although m. styloglossus was observed to originate at the process in the two specimens sectioned in the sagittal plane, it was difficult to determine with certainty whether any fibers attached to the ligament. This was because it was difficult to identify the ligament in the sagittal plane.

Variability of the Relative Length and Bulk of the M. Styloglossus

Differences in the relative length and bulk of the extrinsic portion of m. styloglossus were observed bilaterally within specimens as well as among the fourteen specimens examined. Bilateral differences, although minimal, were observed in eight of the twelve transversely and coronally sectioned specimens in which the muscle was traced bilaterally. Although no systematic source of variability could be identified, the extrinsic portion of m. styloglossus was observed to have greater bulk on the right than on the left side in three specimens (Figs. 4, 5, 11) and greater bulk of the left than on the right side in five specimens (Figs. 8, 9, 10, 12, 14). Bilateral differences in bulk were not apparent in four of the twelve specimens (Figs. 6, 7, 13, 15). The relative length of this portion of the muscle appeared to be uniform in all twelve specimens, bilaterally.

When fourteen specimens were compared, the relative length and bulk of the extrinsic portion of m. styloglossus in each was categorized as either short and thick, long and thin, or long and thick. This portion of the muscle was described as long and thin in eight specimens (Figs. 4, 6, 7, 10, 12, 13, 16, 17), as short and thick in four specimens (Figs. 5, 8, 14, 15), and as long and thick in two specimens (Figs. 9, 11). Although the length of the extrinsic portion of m. styloglossus did not seem to influence the size or course of any other portion of the muscle, the bulk of the extrinsic portion did seem to influence proportionately the estimated percentage of fibers which turned to course medially in the root of the tongue.

Variability of Medial Excursion of Posterior Fibers

The extent to which the posterior fibers of *m. styloglossus* penetrated to midline varied among the twelve specimens sectioned in the transverse and coronal planes. In nine of the twelve, fibers were observed coursing to and/or penetrating the lateral borders of *m. genioglossus*, the most medial muscle mass in the tongue. In three of the twelve, (Figs. 4, 5, 7), fibers coursed to and/or penetrated fibers of *m. longitudinalis inferior* but did not extend sufficiently medialward to reach *m. genioglossus*.

Of nine specimens in which *m. styloglossus* was observed to be penetrating *m. genioglossus*, three were sectioned in the coronal plane. When the posterior fibers of *m. styloglossus* were compared in the transverse versus coronal planes, the fibers appeared to course more medially in the coronally than in the transversely sectioned specimens. The difference was not thought to be real, but an artifact of the plane of section in which the muscle was viewed. These fibers could not be traced at all in the sagittally sectioned specimens, as the successive sections followed the same medial course as the fibers.

Variability of Anterior Excursion of Lateral Fibers

Variability in the extent to which the lateral fibers of *m. styloglossus* coursed anteriorly was difficult to determine for two reasons. First, in the anterior third of the tongue, fibers of *m. styloglossus* merged and intermingled with fibers from the lamina propria, and fibers from the *mm. hyoglossus* and *longitudinalis inferior*. Consequently, it was difficult to trace the fibers of *m. styloglossus* to their point of termination. Second, the extent to which fibers could be traced to their point of termination was dependent upon the plane of section in which the muscle was viewed. The intermingling of fibers was so apparent in the transverse and coronal planes that the isolation of *m. styloglossus* fibers became impossible beyond a point. However, in the sagittally sectioned specimens examined (Figs. 16, 17), the fibers were isolated and traced to the ventral aspect of the tongue tip. Although there was little difference in the extent of anterior excursion of the two muscles viewed in the sagittal plane, greater evidence is needed to substantiate a conclusion of no variability.

Oblique Fibers From the Lamina Propria

The oblique fibers were observed in eight of the nine specimens sectioned in the transverse plane but were not readily apparent in the coronally or sagittally sectioned specimens. The apparent visibility of the fibers seemed to be dependent upon the plane of section. The fibers were not apparent in the ninth transverse specimen probably because its plane of section was more coronal than transverse.

When these fibers were first observed, it was thought that they were fibers of *m. styloglossus*. They appeared to be continuous with fibers of *m. styloglossus*, coursing anteriorly with fibers of that muscle and terminating in the "anterior arch" in the most ventral aspect of the tongue tip. However, because these fibers were observed arising from the lamina propria, they did not conform to the strict definition of *m. styloglossus*. That is, its fibers were not in fact continuous with fibers originating at the *p. styloideus* and/or *l. stylomandibulare*. Further, it was thought that, because the direction of these fibers was more oblique than the direction of *m. styloglossus*, their vector of pull would be different from that of *m. styloglossus*.

These oblique fibers were easily distinguished from fibers of the *mm. hyoglossus*, *longitudinalis inferior* and *genioglossus* by virtue of their lateral position, and from fibers of the *m. transversus linguae* and *verticalis linguae* by virtue of their direction. The possibility remains, that they may be an intrinsic mass, as yet undocumented. Further investigation of these fibers is needed before their exact nature can be determined.

Observations of Musculus Styloglossus

From Gross Dissection

Origin and Course of Extrinsic Belly of *M. Styloglossus*

M. styloglossus had its attachment by a short tendon to the lateral, superior and medial surfaces at the middle of the *p. styloideus*, and by flat tendonous fibers to the *l. stylomandibulare* (Fig. 18). The muscle lay deep to the glandula submandibularis and lingual nerve, and lateral to the glossopharyngeal nerve in the connective tissue of the lateral pharyngeal space. It coursed from its points of origin in a conical belly, inferiorly, slightly medially and anteriorly to the posterior border of *m. hyoglossus* at the root of the tongue (Fig. 19). Here the fibers of the *mm. styloglossus* and *hyoglossus* were traversed by a neuro-vascular bun-

dle containing the hypoglossal nerve and artery (Fig. 20). At the root of the tongue, fibers from the belly divaricated, sending discrete bundles infero-laterally to m. hyoglossus, and medially into the tongue mass (Fig. 24).

Course of Discrete Bundles of M. Styloglossus

The most posterior bundle diverging from the extrinsic belly of m. styloglossus, coursed inferiorly from that belly. The bundle remained lateral to m. hyoglossus, and terminated among the posterior fibers of m. hyoglossus and fibers of m. constrictor pharyngis medius, just medial to the inferior surface of the greater horn of the hyoid bone (Fig. 24). Moving superiorly, the next three bundles coursed inferiorly and anteriorly, and interdigitated with two or three thin, vertical layers of posterior fibers of m. hyoglossus. These bundles terminated, by minute tendons, in the connective tissue investment between the layers of m. hyoglossus (Fig. 21).

Moving more superiorly, the next four bundles coursed inferiorly and more anteriorly than the bundles described above. These bundles also interdigitated with thin, vertical layers of m. hyoglossus. They reached the anterior border of m. hyoglossus, continued anteriorly to weave through thin, horizontal layers of m. genioglossus, then terminate in the median septum (Fig. 22).

In the most superior position, several bundles laying lateral to m. hyoglossus and just inferior to m. longitudinalis superior, coursed in a flat, thin mass, to the tip of the tongue. With the mucosa linguae stripped away, the anterior portion of these m. styloglossus fibers, which coursed ventro-medially at the tip, appeared to separate m. genioglossus from the anterior free margin of the tongue (Fig. 23). Posteriorly, the superior fibers of these bundles were interlaced along their long axis with fibers of the mm. palatoglossus and longitudinalis superior (Fig. 22). Anteriorly, the superior fibers of these bundles were interlaced with fibers of the m. longitudinalis superior only (Fig. 22).

Finally, nine bundles containing the most superior and medial fibers of m. styloglossus, coursed medially from the extrinsic belly of the muscle, and entered the posterior third of the tongue mass just inferior to the m. longitudinalis superior (Fig. 23). These bundles first penetrated vertical fibers of m. hyoglossus, then intersected longitudinal fibers of m. palatoglossus. The fibers of m. styloglossus, continuing medially, then intersected fibers of the m. longitudinalis inferior and penetrated vertical bundles of m. genioglossus. These fibers appeared to terminate in the connective tissue septa between the lateral and medial portion of the m. genioglossus.

Comparison of M. Styloglossus in Fetal and Adult Specimens

Several differences were apparent when the observations of m. styloglossus in fetal specimens were compared with those from gross dissection of an adult specimen. These differences were in the relationship of lateral m. styloglossus fiber bundles to fibers of mm. hyoglossus and genioglossus and in the presence of oblique fibers from the lamina propria.

In the adult specimen, several fiber bundles coursed inferiorly from the extrinsic belly of m. styloglossus. They terminated either lateral to the posterior border of m. hyoglossus, medial to the inferior rim of the greater horn of the hyoid bone or in between successively antero-medial layers of m. hyoglossus. In addition, several bundles coursed infero-anteriorly through vertical layers of m. hyoglossus to penetrate horizontal layers of m. genioglossus and finally terminate in the median septum.

These bundles were not readily apparent in the fetal specimens observed. The primary reason is that in the fetal specimens, the p. styloideus, hyoid bone, and mandible lie in close proximity. These structures are compressed and are essentially parallel on an horizontal plane. Thus, the mm. styloglossus, hyoglossus and genioglossus form very acute angles of intersection with, or are parallel to one another. With the downward and forward growth of the face and masticatory apparatus from the cranial base, considerable change occurs in the length of muscle fibers, their dispersion, and direction of pull, and the angle of intersection between the muscles. Therefore, these fiber bundles, although present in fetal specimens, may not have been discernable as discrete bundles because their final anatomic position had not yet been obtained.

In the fetal specimens sectioned in the transverse plane, oblique fibers from the lateral lamina propria, initially confused with anterior fibers of m. styloglossus, were observed.

These fibers were also observed in the adult specimen during gross dissection. They appeared to arise out of the lamina propria at the lateral borders of the anterior third of the tongue, and were interlaced with superolateral fibers of *m. styloglossus*. Although in the sectioned fetal specimens these fibers appeared to be located inferior to *m. longitudinalis superior*, in the adult they were lateral to and almost indistinguishable from fibers of *m. longitudinalis superior*. Because the lateral extent of the latter muscle has not been clearly defined, it was difficult to determine, even in gross dissection, whether the oblique fibers were fibers of an identifiable muscle mass of a previously unidentified intrinsic muscle mass.

DISCUSSION

The purpose of this study was to observe and describe the morphology of *m. styloglossus* in the human fetus. The study of the fetus was in part based on the hypothesis that the muscular interrelationships in the fetal tongue were essentially the same as those in the adult tongue. That is, growth was not expected to alter the antero-posterior, infero-superior or medio-lateral position of muscles in relationship to other muscles within the tongue mass. This hypothesis was confirmed when the observations from this study were compared with those of adult specimens reported in the literature. However, it was noted that the angles of extrinsic muscular interrelationships appeared to change with growth from the fetus to the adult, as did the final relative positions of some of the muscle fibers. This seemed to be a consequence of the muscles having to continually readjust to bony attachments which are constantly remodeled during active growth periods.

Data from the present investigation supported the observations of previous investigators (Blandin, 1832; Soemmering, 1841; Cruveilheir, 1844; Salter, 1852; Abd-El-Malek, 1939) that *m. styloglossus* originated from two points of attachment: the *p. styloideus* and the *l. stylomandibulare*. However, variability of attachments, not previously reported, was found among the specimens in this study. Double attachments were noted in nine of twelve specimens. In two of the twelve, *m. styloglossus* attached to only one point of origin, the *p. styloideus*. In one of the twelve, the muscle originated from the ligament only.

In the fetal specimens observed in this study, the course of the extrinsic portion of the muscle was more anterior and medial than inferior as found in the dissected adult specimen and described in the literature. This finding may be related to the fact that in the fetus, the *p. styloideus*, mandible and hyoid bone are compressed into the same plane and lay in an essentially parallel relationship to one another. With growth, the mandible carries the face and tongue downward and forward from the cranial base. One result of this process is that fibers of *m. styloglossus* become elongated and are drawn inferiorly from their point(s) or origin.

A clear definition of the interrelationships between *m. styloglossus* and the *mm. hyoglossus*, *palatoglossus* and *longitudinalis superior* at the root of the tongue could not be found in the literature. In the present study, it was noted that at the root of the tongue fibers of *m. styloglossus* lay lateral to vertical fibers of *m. hyoglossus* and inferolateral to *m. longitudinalis superior* and longitudinal fibers of *m. palatoglossus*.

The division of *m. styloglossus* into portions at the root of the tongue was observed in specimens examined by Cruveilheir (1844), Salter (1852) and Abd-El-Malek (1939), as well as in specimens examined during the present study. Cruveilheir (1844) described external and internal portions; Abd-El-Malek (1939) described upper and lower portions; the present investigator, anterior and posterior portions. Regardless of the terminology, the observed division and subsequent course reported in each of the studies was similar. There was greater agreement with respect to the extent of the anterior fiber course than with respect to the extent of the posterior course. In the present study, the anterior fibers were observed to course along the lateral margin of the tongue, lateral to *m. hyoglossus* and infero-lateral to *m. longitudinalis superior*, toward the ventral aspect of the tip of the tongue. Near the tip, the fibers merged with fibers of the *mm. hyoglossus* and *longitudinalis inferior* and oblique fibers from the lamina propria. Salter (1852), Abd-El-Malek (1939) and Miyawaki (1973) also described the convergence of the *mm. styloglossus*, *hyoglossus* and *longitudinalis inferior*. In addition, Salter (1852) described "lateral lingual" fibers which were formed by this convergence. Abd-El-Malek (1939) reported that fibers of *m. genioglossus* were also seen to converge toward the tongue tip. This was not a finding of the

present study.

Only one investigator (Cruveilhier, 1844) described fibers similar to the oblique fibers from the lamina propria observed in the present study. Cruveilhier (1844) stated that a layer of oblique fibers passed downward and forward from the sides of the tongue. However, his fibers were found toward the base of the tongue, not toward the tip. The present investigator was not able to determine precisely what fibers were described by Cruveilhier (1844), since the readily apparent obliquely directed fibers in the base of the tongues observed in this study were identifiable as distinct muscles of the tongue.

Among the previous investigators, only Abd-El-Malek (1939) described the insertion of anterior m. styloglossus fibers. He reported that the fibers inserted, along with the fibers of the mm. hyoglossus, longitudinalis superior and inferior, and genioglossus, into the anterior arch. The results of this study partially confirmed his observation; that is, in fetal specimens, fibers of the mm. longitudinalis superior and inferior, hyoglossus and the oblique fibers were clearly observed attaching to the anterior arch. Although fibers of m. styloglossus could not be traced after their convergence with the adjacent muscles, it is quite probable that they, too, continued anteriorly to attach to that arch. In the dissected adult specimen, anterior fibers of m. styloglossus clearly coursed anteriorly, rotated ventro-medially and inserted into the mucosa at the tip of the tongue, inferior to the mm. longitudinalis inferior and hyoglossus. The term mucosa is used here since the anterior arch was much less apparent as a distinct structure in the adult specimen than in the fetal specimens. These findings supported Miyawaki's (1973) observation that some of the anterior fibers of m. styloglossus rotated ventrally to lay inferior to fibers of m. longitudinalis inferior.

During the dissection portion of this study, several bundles of the anterior portion of m. styloglossus were found to be separated from the main anterior portion. They did not course to the tongue tip, but more inferiorly and inserted at various points into layers of m. hyoglossus. A few of those bundles were traced infero-anteriorly to the horizontal layers of m. genioglossus which they penetrated in their course to the median septum. These bundles of m. styloglossus were not described in the literature, nor were they apparent in the sectioned specimens in this study. The fact that these bundles were not apparent in the fetal tongues may again be related to the influence of growth. Whereas, the bundles assume a horizontal course in fetal specimens and form acute angles of intersection with fibers of m. hyoglossus, in the adult, the angles of intersection are obtuse as a result of the modifications which occur with growth.

Another source of disagreement in the literature concerned the course of the posterior fibers of m. styloglossus. While Cruveilhier (1844) observed that m. styloglossus penetrated m. hyoglossus to blend with m. transversus linguae, other investigators observed only the superficial interrelationship between the posterior fibers of m. styloglossus and postero-lateral fibers of m. hyoglossus. None reported the point(s) of insertion for these fibers. The data from the present study indicate that the posterior fibers of m. styloglossus turned medialward at the lateral border of m. hyoglossus, penetrated that muscle, and in a transverse direction coursed medially toward midline. In most of the specimens observed, including the dissected specimen, the fibers terminated in the connective tissue septa lateral to or in the medial aspect of m. genioglossus.

Descriptions of the number or percentage of fibers in the anterior and posterior portions of m. styloglossus could not be found in the literature. Data from the present investigation demonstrated little variability in the estimated percentage of fibers in each portion of the fetal muscle. An estimated 75 per cent of the fibers coursed medially; the remaining 25 per cent coursed anteriorly. However, in the dissected adult specimen, approximately 50 per cent of the fibers coursed in each direction.

It should be noted that the percentage of fibers in each segment was estimated from the composite tracings of the muscle in fetal specimens, while fiber bundles were actually counted during dissection of the adult specimen. In addition, the perception of a smaller percentage of anterior fibers in the fetal specimens may have been due to the fact that in those specimens, fibers coursed toward the tip of the tongue in compact parallel bundles, while in the adult they were dispersed infero-superiorly.

No descriptions of muscle length or bulk were found in the literature. While direct measurements were not obtained, variability of relative length and bulk were noted among

specimens observed in this study. This variability may have been true anatomical variability among specimens of the same age, or it may have been an indication of developmental differences in fetal specimens whose ages were estimated based on variable dimensions.

Suggestions for Further Research

In order to determine the length and bulk of *m. styloglossus* and the number of fibers coursing anteriorly and medially, fiber counts and/or measurements of cross-sectional area are needed. Direct measurements would be useful in accurately determining the variability of muscle size. The percentage of fibers in such portion (anterior and posterior) of the muscle may have functional significance. That is, a disproportionate number of fibers in either portion of the muscle could influence the degree to which the muscle participates in either the transverse or longitudinal system of fibers in the tongue, and would thus influence the functional capability of the muscle as a whole. While it is apparent from the present research that the posterior fibers do not course sufficiently medialward to attach to fibers from the opposite side, they do appear to form a transverse sling with fibers of the *m. transversus linguae* in the base of the tongue. The functional significance of that sling is worthy of investigation.

Only *m. genioglossus* has been studied electromyographically (MacNeilage & Shales, 1964; Bole & Lessler, 1966; Cunningham & Basmajian, 1969). Based on its anatomical location, *m. styloglossus* can probably best be approached electromyographically by inserting needle electrodes intraorally into the base of the palatoglossal arch where fibers of its extrinsic belly lay just inferior to fibers of *m. palatoglossus*. Also, the anterior fibers of *m. styloglossus* can be approached superficially by placing a needle or surface electrode in or onto the lateral margin of the tongue. The location of *m. styloglossus* fibers along that margin can be seen beneath the mucosa when the tongue is forcefully lateralized to one side.

The oblique fibers arising antero-laterally from the lamina propria observed in this study have not been described by previous investigators. Cruveilhier's (1844) oblique fibers were only observed toward the base of the tongue. The morphology of these fibers needs to be investigated in order to determine whether they are a distinct muscle mass, fibers belonging to an identifiable muscle mass such as *m. styloglossus*, or a conglomeration of fibers from several adjacent muscles.

Finally, it is apparent from the literature reviewed that all 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 morphological and physiological 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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Figure 4. Composite Female Specimen No. 3-1093. Transverse. Mag. 13X

The muscle origin is at the p. styloideus (PS) and 1. stylomandibulare, bilaterally. The muscle on the left side is attached to the superior and lateral surfaces of the process, near its apex. On the right side it is attached to the medial, superior and lateral surfaces of the process at its apex. The extrinsic belly is long and thin bilaterally but has slightly greater bulk on the right than left side. A greater number of fibers are seen coursing medially from the right extrinsic belly. Those fibers coursing medially on the right also have a slightly greater range of dispersion antero-posteriorly, and appear to project closer to midline than those on the left. Lateral fibers of m. styloglossus (SG) were traced anteriorly to approximately the same point, bilaterally. The arrow indicates fibers in cross-section which probably course inferiorly.

Fig. 4a. Section No. 284. The most superior fibers of the extrinsic belly of m. styloglossus (SG) are seen on the right side.

Fig. 4b. Section No. 272. The p. styloideus (PS) is seen bilaterally. Extrinsic and intrinsic portions of m. styloglossus (SG) are present bi-laterally.

Fig. 4c. Section No. 264. The p. styloideus (PS) is visible only on the left. Fibers coursing medially are apparent bilaterally.

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Fig. 4d. Section No. 232. The hyoid bone (HB) is visible bilaterally. Posterior fibers of m. styloglossus (SG) can be seen penetrating bundles of m. hyoglossus (HG) which are present in cross-section. A few fibers of m. styloglossus (SG) can be followed anteriorly, bilaterally. Oblique fibers (OF) are present bilaterally, beginning approximately at the most anterior bundle of m. hyoglossus (HG).

Fig. 4e. Section No. 224. Posterior fibers of m. styloglossus (SG) are seen penetrating fibers of the musculli hyoglossus (HG) and longitudinalis inferior (IL) bilaterally. On the left, the posterior fibers approach the lateral border of m. genioglossus (GG). Anteriorly, oblique fibers, and fibers of the musculli styloglossus (SG) and m. longitudinalis inferior (IL) are seen converging.

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Fig. 4f. Section No. 200. Lateral fibers of m. styloglossus (SG) are still present bilaterally, but cannot be traced to the tip.

Origin is at the p. styloideus (PS) by short tendons, bilaterally. The extrinsic belly is short and thick bilaterally, with the right belly having slightly greater bulk than the left. The right belly appears to be slightly longer than the left. There is little difference in the medial and anterior excursion of fibers bilaterally.

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Figure 6.

Composite Female Specimen No. 3-838. Transverse. Mag. 14X

M. styloglossus (SG) has its origin at the p. styloideus (PS) and l. stylomandibulare, bilaterally. Its attachments are to the lateral and superior surfaces near the middle of the processes. The extrinsic belly is long and thin bilaterally. Fibers of the left belly appear to be more compact than the right. More fibers can be seen coursing medially from the extrinsic belly on the left side. Little difference is noted in the degree to which the fibers were traced bilaterally, toward midline or toward the tip.

Figure 7.

Composite Female Specimen No. 3-714. Transverse. Mag. 13X

The muscle originates at the apex of the p. styloideus (PS) and the 1. stylomandibulare, bilaterally. The extrinsic bellies are long and thin and do not differ bilaterally, in apparent bulk or length. Fibers coursing medially from each belly project only a short distance toward midline, but do so over a rather broad antero-posterior area in the tongue root. Lateral fibers could not be traced ver far, anteriorly.

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Figure 8.

Composite Male Specimen No. 3-198. Transverse. Mag. 15X

The m. styloglossus (SG) originates at the 1. stylomandibulare, below and lateral to the apex of the p. styloideus (PS). The extrinsic bellies are short and thick bilaterally. However, the left belly appears to have greater bulk and the right belly appears to have greater length. More fibers appear to course medially from the right belly than from the left. When the lateral fibers are viewed, a greater number of fibers seem to course anteriorly from the extrinsic belly on the left than on the right.

Figure 9.

Composite Male Specimen No. 3-297. Transverse. Mag. 13X

The m. styloglossus (SG) originates at the p. styloideus (PS) and 1. stylomandibulare, bilaterally. Attachment to the left process is on the lateral, superior and medial surfaces, near the middle of the process. Attachment to the right process is on the lateral surface near the middle of the process. The extrinsic belly of the muscle is long and thick bilaterally, with the left having greater bulk. The left belly also appears to send more fibers medially than the right. The lateral bundles are quite thin bilaterally and appear to be short or broken because they were intersected along their length, by fibers of the m. transverse linguae. The arrows indicate fibers in cross section which probably course inferiorly.

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Figure 10.

Composite Male Specimen No. 3257. Transverse. Mag. 13X

M. styloglossus (SG) is attached to both the p. styloideus (PS) and l. stylomandibulare, bilaterally. Attachments to the processes are on the lateral, superior and medial surfaces, near their middle, bilaterally. The p. styloideus (PS) are long and thin bilaterally and curve antero-medially. Note the relationship of both processes to the hyoid bone (HB). The extrinsic bellies are long and thin, with the left having slightly greater bulk, and sending more fibers medially, than the right. The lateral bundles are thin bilaterally and appear to be short or broken because they were penetrated along their length by fibers of m. transverse linguae (TR).

Figure 11.

Composite Male Specimen No. 3-302. Transverse. Mag. 13X

(Note: This specimen was misshapen and showed evidence of tissue damage during histological preparation. The mandible had been removed prior to preparation and Meckel's cartilage could be observed in only a few sections on the left side. The specimen was sectioned on a plane divergent from the horizontal such that the right side was below and the left side above the horizontal plane.) M. styloglossus (SG) has its origin at the p. styloideus (PS) and l. stylomandibulare, bilaterally. The attachment to the ligament on the right is quite prominent. Origin at the process is on the lateral surfaces bilaterally. The extrinsic bellies are long and thick, with the right having greater bulk than the left. Many more fibers are seen to course medially from the belly on the right. The posterior fibers appear to cover a broad antero-posterior region in the root of the tongue, bilaterally. No substantial difference is seen between fibers coursing anteriorly, bilaterally.

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Figure 12.

Composite Male Specimen No. 3-183. Transverse. Mag. 15X

(Note: This specimen appeared to be sectioned in a plane in between the standard transverse and coronal planes. In addition, its mandible had been removed, and with it the Meckel's Cartilage.) M. styloglossus (SG) is attached to the medial, superior and lateral surfaces of the p. styloideus (PS), bilaterally. The extrinsic bellies are relatively long bilaterally, and the right is of greater bulk than the left. Very few fibers are seen coursing medially from the extrinsic bellies. Instead, most of the fibers course anteriorly along the lateral borders of the tongue.

Figure 13.

Composite Female Specimen No. 3-1004. Coronal. Mag. 15X

M. styloglossus (SG) attaches to both the p. styloideus (PS) and the l. stylomandibulare bilaterally. The double origin is most apparent on the right side. The extrinsic bellies are long and thin with no apparent bilateral differences in the relative length and bulk of the bellies. Posterior fibers appear to closely approximate midline. Lateral fibers course ventrally but their anterior excursion cannot be determined in this composite.

Figure 14.

Composite Female Specimen No. 3-222. Coronal. Mag. 15X

M. styloglossus (SG) attaches to the p. styloideus (PS) and the 1. stylomandibulare bilaterally, although neither of these points of origin are shown. The muscle has a short, thick irregularly shaped extrinsic belly, bilaterally. A large number of fibers course medially toward midline, the greater number from the left than the right belly. The inferior extent of the muscle is apparent although the anterior extent is masked in composites in this plane.

Fig. 14a. Section No. 582 M. styloglossus (SG) is attached to the lateral, superior and medial surfaces of the p. styloideus (PS). The muscle is seen in relationship to the musclic stylopharyngeus (SP) and stylohyoideus (SH), bilaterally. The m. stylohyoideus (SH) is seen coursing around the intermediate tendon of the m. digastricus (DT). Note the hyoid bone (HB) and thyroid cartilage (TC).

Fig. 14b. Section No. 546. M. styloglossus (SG) nearly penetrates the tongue mass, bilaterally.

Fig. 14c. Section No. 526. On the right fibers of m. styloglossus (SG) penetrate bundles of m. hyoglossus (HG). Fibers of m. styloglossus (SG) are seen coursing inferiorly at the lateral borders of m. hyoglossus (HG), bilaterally. Note the chondroglossus fibers of m. hyoglossus (HG) coursing vertically into the body of the tongue.

Fig. 14d. Section No. 494. Fibers of m. styloglossus (SG) course medially to penetrate m. hyoglossus (HG) and merge with fibers of m. transversus linguae (TR) at the lateral borders of m. genioglossus (GG).

Fig. 14e. Section No. 482. A large group of fibers are seen penetrating bundles of m. hyoglossus (HG) on the left. Several fibers are seen coursing medially on the right.

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Figs. 14f. & g. Section No. 442 & 374. No posterior fibers of m. styloglossus (SG) are visible. In these sections, m. styloglossus (SG) is seen projecting inferiorly along the lateral borders of m. hyoglossus (HG).

Fig. 14g. Section No. 374

Figure 15.

Composite Male Specimen No. 3-1528. Coronal. Mag. 15X

Bilateral attachment is to both the p. styloideus (PS) and the 1. stylomandibulare (LSM), although these points of origin are not shown. The muscle is short and thick bilaterally and bilateral differences in the relative length and bulk are not readily apparent. Fibers of m. styloglossus (SG) on the left, course medially to penetrate m. genioglossus (GG). The number of fibers coursing medially appears to be equivalent to the number coursing inferiorly and anteriorly, bilaterally. The lateral fibers appear to course inferiorly, then anteromedially. The most anterior fibers lay inferior to fibers of m. hyoglossus (HG) and m. longitudinalis inferior (IL), projecting almost to the lateral borders of m. genioglossus (GG).

Figure 16.

Composite Female Specimen No. 3-238. Sagittal. Mag. 15X

The lateral aspect of m. styloglossus (SG) can be seen as it courses in the ventral aspect of the tongue, anteriorly from its origin on the superior surface of the apex of the p. styloideus (PS) to its insertion in the tip of the tongue. The muscle appears to course horizontally in this plane.

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Figure 17.

Composite Male Specimen No. 3-903. Sagittal. Mag. 15X
The length of m. styloglossus (SG) is from the superior surface of the p. styloideus (PS) to a short distance posterior to the tip.

Figs. 17a & b- Sections No. 328, and 384. M. styloglossus (SG) is seen in relationship to the superior surface of the p. styloideus (PS) and to the muscoli stylopharyngeus (PS) and stylohyoideus (SH). M. stylohyoideus (SH) is seen coursing around the intermediate tendon of m. digastricus (DT). In fig. 17b, fibers of m. styloglossus (SG) deviated slightly superiorly to course around the superior surface of the glandula submandibularis (not shown).

Figure 17b. Section No. 384

Fig. 17c. Section No. 424. Fibers of m. styloglossus (SG) have penetrated a thin vertical layer of m. hyoglossus (HG). Fibers of both the m. palatoglossus (PG) and m. constrictor pharyngis superior or the pars glossopharyngeus (GP) are seen coursing from the palate. Note fibers of the muscili hyoglossus (HG) and longitudinalis superior (SL) in the tongue mass.

Fig. 17d. Section No. 435. Fibers of m. styloglossus (SG) are seen in relationship to m. hyoglossus (HG), as they course anteriorly along the lateral aspect of the tongue.

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Fig. 17e. Section No. 444. M. styloglossus (SG) is seen coursing in the ventro-lateral aspect of the tongue, anteriorly to the tongue tip. Note the relationship of the muscoli hyoglossus (HG), longitudinalis inferior (IL) and longitudinalis superior (SL).

Figure 18. With the mandible removed, the anterior and posterior bellies of m. digastricus (DIG), and the extrinsic belly of m. styloglossus (SG) are visible. The latter is attached to the p. styloideus, but squared tendonous fibers have been detached from the 1. stylomandibulare.

Figure 19. The musculi mylohyoideus (MH) and geniohyoideus (GH) are reflected and the glandula sublingual is removed. Note the relationship of the musculi styloglossus (SG) and hyoglossus (HG) to the hypoglossal nerve (HN) and reflected lingual nerve (LN).

Figure 20. The overlying fascia has been removed to show the m. hyoglossus (HG) coursing vertically. That muscle is covered by the hypoglossal nerve (HN). Several divergent bundles are seen coursing from the extrinsic belly of m. styloglossus (SG). The lingual nerve and artery (LN) are seen separating m. genioglossus (GG) from the body of the tongue.

Figure 21. Layers of m. hyoglossus (HG) have been dissected out of the lateral border of the tongue so that the course of m. styloglossus (SG) fibers can be traced. M. styloglossus has been detached from both the process and ligament. The squared tendonous fibers which were attached to the ligament are clearly visible. Longitudinal fibers of m. palatoglossus (PG) are seen superior to m. styloglossus.

Figure 22. Fibers of m. styloglossus (SG) can be seen penetrating layered horizontal bundles of m. genioglossus (GG) as they course toward the median septum.

Figure 23. Posterior fibers of m. styloglossus (SG) are seen coursing medialward just inferior to fibers of the musculus palatolinguinalis superior (SL). Note fibers of m. longitudinalis inferior (IL) and genioglossus (GG).

Figure 24. Fibers of m. styloglossus (SG) have been dissected out so that they appear in relief.

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