Muscle Patterns of the Late Fetal Tongue Tip

WILLIAM A. BELL, D.D.S.

The tongue can be considered a mucosal envelope filled with skeletal muscle.[1,2] Movement of the tongue is effected by a complex musculature which is distinctive in its interlacing arrangement.[3,4] This study will describe the normal histologic muscle patterns of the infant tongue tip.

EMBRYOLOGY

The complex musculature of the infant tongue may be best understood by examining the development of this unique organ (Fig. 1). The oral cavity is formed in the human embryo at the 3.5 mm stage by an invagination of ectoderm.[1,5] On the ventral surface of the newly formed oral cavity are two raised mounds of tissue referred to as the primordial tongue. These ventral thickenings arise from the area of the first and second branchial arches. At this early stage the tissue underlying the epithelium is composed of primitive stellate mesenchymal cells with a delicate fibrous stroma; no muscle differentiation has occurred. The tongue's subsequent growth is characterized by proliferation, migration, and fusion. The tuberculum impar, prominent during early embryogenesis, is soon obscured by the developing lateral halves, as depicted in the diagram. The tongue mucosa is derived from two different germ layers, ectoderm anteriorly, and foregut entoderm around the terminal sulcus posteriorly.

Differentiation of the tongue musculature begins at the 26 mm stage and is essentially complete at approximately five months' gestation.[1] Lewis,[6] in 1910, suggested that tongue skeletal muscle was formed directly from primitive mesenchyme in the floor of the oral cavity. More recent studies, however, support the concept of a dual origin from both the floor of the mouth and from the occipital and cervical segments. Studies by Hunter[7] in the chick and by Bates[8] in the cat pointed to a dual origin of tongue muscle; and a definitive study by Deuchar[9] demonstrated muscle migration to the tongue with carbon labeling of cervical and occipital somites in the chick embryo.

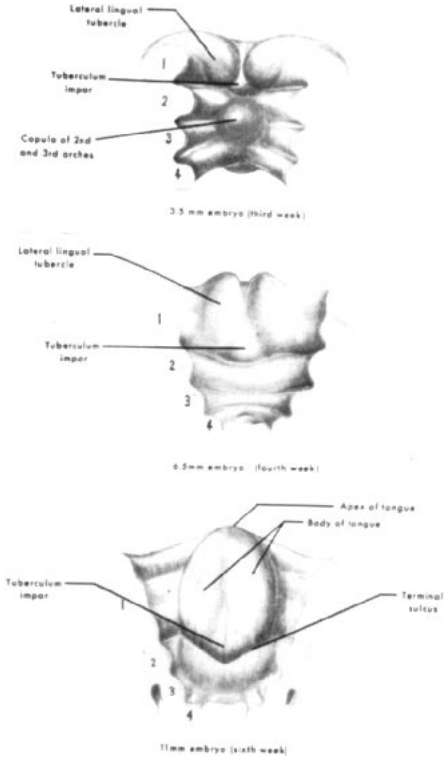

Fig. 1 This sequence, done in halftone, demonstrates how the tongue forms from the floor of the oral cavity during 3.5 to 11 mm stages. Drawn by Keiko Moore from D. K. Winter's Armed Forces Institute of Pathology illustration.

From the National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, Maryland 20014.

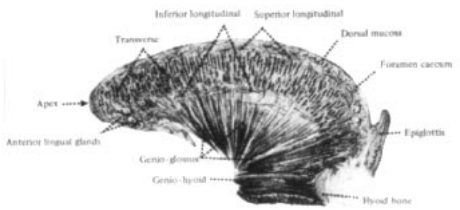

Fig. 2 Sagittal view of newborn tongue, adapted from Werner Spalteholz, Hand Atlas of Human Anatomy, J. B. Lippincott Co.

Tortella[10] examined human embryos from 15 to 27 mm and described a similar progressive somatic muscle migration from cervical somites.

Anatomy

The intricate musculature of the tongue can be appreciated in Figures 2 and 3. Attention will be directed particularly to the muscular architecture of the tongue tip which displays two distinct muscle patterns, intrinsic and extrinsic groups.[11,12,13,14] Most of the tongue tip is a well-defined mass of intrinsic musculature which can be further identified as transverse, vertical, superior longitudinal, and inferior longitudinal. These individual intrinsic groups cannot be traced, however, as facial planes are lacking and fiber interlacing complicates an orderly dissection. Fibers of the genioglossus can be clearly identified in the sagittal plane inferior to the mass of the intrinsic musculature; however, in the frontal plane the genioglossal fibers intertwine with the intrinsics and precise fiber identification is not possible. Fibers of the styloglossus have been described as extending to the tongue tip. A median fibrous septum extends to the mucosa of the apex.

Histologically, the intertwining of intrinsic muscle groups is readily appreciated; and, as in the gross specimens, intrinsic and extrinsic groups are easily separated. The verticalis can be well demonstrated microscopically. The dorsum of the tongue is covered by a papillary keratinized mucosa which changes abruptly to a smooth, nonkeratinized mucosa at the lateral margins and extends to cover the ventral surface.

The intrinsic fibers insert directly into the reticular lamina propria and thus have a close relationship with the overlying mucosa (Fig. 4). This feature is absent in the ventral mucosa. This close muscle insertion in the dorsal mucosa may be significant in the tongue tip's ability to perform intricate movements.

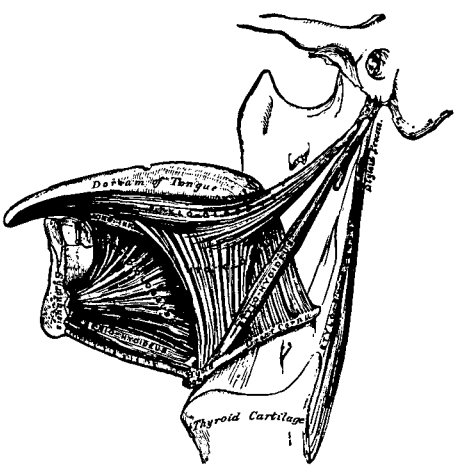

Fig. 3 The Extrinsic Tongue Muscles, from Gray's Anatomy 25th Edition, Lea and Febiger.

Fig. 4 A H&E section of the anterior dorsal surface of an infant tongue tip that reveals a lack of a submucosa, and close attachment of muscle fibers to the covering mucosa. (2.5 X magnification)

The extrinsic muscles, in contrast to the intrinsic, can be followed with relative ease into the tongue. These muscles include: the genioglossus, styloglossus, hyoglossus, palatoglossus, and chondroglossus (Fig. 3). The extrinsic and intrinsic muscles are innervated by the twelfth cranial nerve with the exception of the palatoglossus which is innervated by the pharyngeal plexus of the tenth cranial nerve.

Methods and Materials

The tongue tip has no definite anatomic demarcation. For the purpose of this study, the tongue tip was considered to be the tongue mass between the apex and an arbitrary line 2.5 cm posterior to the tip. Seven neonatal tongue tips and six normal adult tongue tips were fixed in formalin. The specimens were measured and photographed and reference points were made. To demonstrate muscle plans, frontal and sagittal planes were used on the same tongue. These were then sectioned, mounted, stained with hematoxylin and eosin. All slides were cut at seven microns. The study consisted of observing the muscle patterns for similarity and measuring fiber diameters. The measurements were made using a micrometer which fit into the eye piece of a Leitz microscope. Twenty fiber diameter measurements were taken at random on each tip, selecting intrinsic muscle fibers which could be oriented in a horizontal plane.

Results

A definite fiber diameter difference was apparent. The average fiber diameter of the infant tongue tip was 25 microns in contrast to the average fiber diameter of the adult tongue tip of approximately 47 microns, almost a doubling of fiber diameter from newborn to adult. Observation error in measuring any particular fiber was approximately 5 microns. The doubling of fiber diameters from newborn to adult was less than the five-fold increase found by Schafer.[15] Schafer failed however to specify which groups were studied. Histologic patterns of the newborn and adult tongue tips displayed a definite similarity. An interesting pattern was seen in the sagittal section where the vertical muscle fibers are spaced at regular intervals by horizontal fiber bundles (Fig. 5). The presence of this feature in both newborn and adult tongue tips indicated that there is indeed a mature arrangement of skeletal muscle fibers in the infant closely resembling that of the adult.

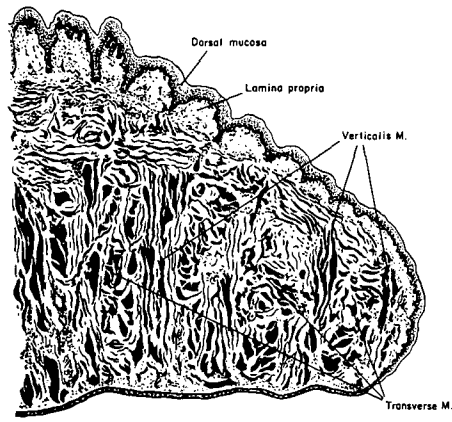

Fig. 5 Line drawing from a sagittal section of an infant tongue tip which demonstrates muscle patterns created by vertical and transverse muscle bundles. (2.5 X magnification, drawn by Keiko Moore)

Studies of gross tongue growth by Hopkins[18] have demonstrated a doubling of size from infancy to adulthood. No observations of microscopic muscle patterns of the infant tongue have been reported. Skeletal muscle biopsy is a proven clinical approach to the diagnosis of neurological and muscular disease. To utilize tongue biopsy as a diagnostic tool, normal muscle patterns must be studied. With standards of normal fiber variability established, mea-

surement of fiber diameter may be used to judge the hyper- or hypotrophic nature of muscle fibers.[16,17] A biopsy of the anterior portion of the tongue could be useful in demonstrating hypoglossal nuclear degeneration or tract interruption. The advantages of an intraoral biopsy include minimal scarring, good accessibility, and a relatively large tissue mass. Microscopically, the tongue muscles are readily studied in both longitudinal and horizontal sections. This study reports a mature muscle architecture in the neonatal tongue tip with an average fiber diameter approximately half that of the adult.

School of Dentistry
Univ. of California
San Francisco, Calif. 94122

References

1. Arey, L. B.: *Developmental Anatomy*, 6th Edition, Philadelphia and London, W. B. Saunders, p. 228, 1954.
2. Patten B. M.: *Foundations of Embryology*, New York, McGraw-Hill Book Co., pp. 403-406, 1958.
3. ABD-EL-Malke, S.: Observations of the morphology of the human tongue, *J. Anat. Lond.*, 73:201-210, 1939.
4. ———— A Contribution to the study of the movements of the tongue in animals, with special reference to the cat, *J. Anat.*, 73:15-30, 1938.
5. Sicher, H.: *Orban's oral histology and embryology*, 6th Edition, St. Louis, C. V. Mosby Co., pp. 2-14, 1966.
6. Lewis, W. H.: *Manual of human embryology*, pp 454-522, 1910.
7. Hunter, R. P.: The early development of the hypoglossal musculature in the chick, *J. of Morphol.*, 57:2, pp. 473-499, 1935.
8. Bates, M. N.: The early development of the hypoglossal musculature in the cat, *Amer. J. Anat.*, 83:329-357, 1948.
9. Deuchar, E. M.: Experimental demonstration of tongue muscle origin in chick embryos, *J. Embryol. Exp. Morpl.*, 6:Part 4, pp. 527-529, 1958.
10. Tortella, E. T.: The development of the shape and musculature of the tongue in man, *Ztschr. f. Ant. u. Entwichl.*, 105:72-78, 1935.
11. Huber, C. G.: *Piersol's human anatomy*, 9th Edition, Philadelphia, J. B. Lippincott Co., p. 1579, 1930.
12. Brach, J. C.: *Cunningham's manual of practical anatomy*, 11th Edition, London Oxford University Press, 3: 314, 1949.
13. Gray H., and Goss, C. M.: *Gray's Anatomy*, 28th Edition, Philadelphia, Lea and Febiger, p. 1189, 1966.
14. Hollinshead, W. H.: *Textbook of Anatomy*, 2nd Edition, New York, Harper and Row, p. 902, 1962.
15. Shafer, E. A.: *Textbook of Microscopic Anatomy*, 11th Edition, New York, New York Longman's & Co., 2:193-194, 1912.
16. Adams, E. R., Denny-Brown, D., and Pearson, C. M.: *Diseases of Muscle*, New York, Paul B. Hoeber, Inc., p. 9, 1953.
17. Goss, R. J.: Hypertrophy versus hyperplasia, *Science*, 153:1615-1620, 1966.
18. Hopkins, G. B.: Neonatal and adult tongue dimensions, *Angle Orthodont.*, 37:132-133, 1967.