The infrahyoid muscle group (*Mm. infrahyoidei*) in Formosan monkey

By

Ryosuke Miyauchi

Department of Anatomy, Faculty of Medicine,
Nagasaki University, Nagasaki, Japan
(Director: Prof. J. Satoh)

The muscles of the neck may grossly be classified into the deep and superficial groups. The superficial group is further divided into the lateral and medial musculature with further subdivision of the medial muscle group into the suprahyoid and infrahyoid groups. In this report the infrahyoid group shall be described.

The material consists of 25 formalin fixed bodies of adult Formosan monkey (*Macaca cyclopis*, *Swinhoe*), (male 12, female 13) selected at random from among the specimens collected by Satoh and preserved in this department.

In all cases, magnifying lenses for dissection purposes were used in order to insure accuracy of the findings.

Findings and Consideration

The four muscles including the *M. sternohyoideus*, *M. sternothyreoideus*, *M. omohyoideus* and the *M. thyreochoideus* not only comprise the so-called infrahyoid group from the standpoint of regional anatomy, but also are embryologically closely related to each other and are said to have differentiated from the same embryonic anlage (Fig. 1).

1. *M. sternohyoideus*

This band-like muscle, located in the superficial stratum at the midline of the anterior neck, runs parallel and adjacent to its companion of the opposite side.

Generally it arises from the upper margin of the dorsal (posterior) surface of the manubrium sterni (86%), and there may be ad-

Fig. 1

ditional muscle bundles from the sternal end of the clavicle (10%) (Fig. 2-a) or from the dorsal (posterior) surface of the junction of the sternocostal cartilage of the first rib (4%) (Fig. 2-b).

Fig. 2 Variations of origin of the *m. sternohyoideus*

The lower edge of the attachment of the origin of this muscle to the dorsal surface of the sternum is at the level of the sternal angle (level of the second costal cartilage).

The insertion is into the lower edge of the body of the hyoid bone and the outer margin of the insertion is fused with the tendon of insertion of the *M. omohyoideus* (Fig. 3-a, b, c).

In all cases, a tendinous inscription is seen on the deep surface of this muscle in the region near its origin from the manubrium sterni (about 1 cm above the upper edge of the manubrium sterni).

Furthermore, the muscles on each side are fused together in the region of this tendinous inscription and in the region extending from the origin to the upper edge of the sternum. Particularly, in the region of the tendinous inscription, there is not only continuation of the muscle bundle into the muscle of the opposite side but also occasionally continuation with the muscle bundle of the *M.*

Fig. 3-a (ventral view) Origin and insertion of m. thyreohyoideus.
Insertion of m. sternohyoideus

Fig. 3-b (lateral view)

Fig. 3-c (dorsal view)

sternothyreoides of the other side. In other areas, the muscles of each side are simply adjacent. Moreover, in the area from the origin to the tendinous inscription, there is fusion of this muscle with the M. sternothyreoides.

The origin of this muscle in primates usually extends down to the manubrium sterni (Eisler) and particularly in such Prosimiae as Lemur it extends as far as the third costal cartilage (Murie & Mivart, Oishi, Eisler) while even in Macacus it may occasionally extend to the level of the third costal cartilage (Oishi). In my cases of *Macaca cyclopis*, however, it ended at the level of the second costal cartilage.

In man, there apparently are considerable racial differences, but in general the origin is usually from the sternum and the clavicle (74.4% of Japanese, Morishita; 40% of Poles, Loth). The type in which the origin is limited only to the sternum such as in the majority of *Macaca cyclopis* (88%) is infrequent among man (11.6% in Japanese, Morishita; 30% in Poles, Loth).

The tendinous inscription has been reported to be present in Lemur, Cebus, Semnopithecus (Oishi), Macacus (Oishi, Howell and Straus), etc., and besides there are some authors who claim it to be consistently present in lower monkeys (Eisler, Kohlbrügge, Loth). Among anthropoid apes, however, the situation varies by the species and though it is definitely present in gorilla, it frequently is absent in other anthropoid apes (Eisler, Loth). Re-

ports on gibbons are inconsistent, some mention its presence (Kohlbrugge) while others state that it is absent (Oishi).

The presence of the tendinous inscription is frequently found in man (70% in Japanese, Adachi; 36.6% in newborn, Morishita; 17% in fetus, Yonekura) and seems to decrease in frequency in the lower age group. On the other hand, Loth has reported it at a frequency of 44% in Europeans, and 66% in Negroes while Wagenseil has reported its presence in 23% of Chinese.

The insertion of this muscle in Simiae is similar to *Macaca cyclopis*, generally being the body of the hyoid bone, but in gibbons (Oishi) and chimpanzee (Testut), it occasionally may separate into two parts, forming an accessory insertion into the greater cornu of the hyoid bone.

As in *Macaca cyclopis*, fusion with the *M. sternothyroideus* may usually be seen in the area from the origin to the tendinous inscription in other lower monkey and *Semnopithecus*, etc. and further union with the companion on the opposite side also is said to be common (Kohlbrugge), but such fusion between each side has also been reported in orang-outan (Fick, Michaelis).

Such separation or duplication of this muscle (Macalister, Testut, etc.) or absence of this muscle (Chudzinski, Quain-cited from Eisler) as reported in rare cases among man could not be found.

2. *M. sternothyroideus*

This muscle, slightly greater in width than the *M. sternohyoideus*, is located on the lower surface (dorsal side) of this muscle. As it courses upward toward the insertion, the muscles of each side separate from each other to run to the lateral neck.

In general, this muscle arises from the posterior surface of the manubrium sterni (94%) and in some cases in addition to the muscle bundle arising from the sternum, there may be an additional muscle bundle from the first sternocostal junction and the second sternocostal joint (4%) (Fig. 4-a) or additional muscle fibers from the sternal end of the clavicle (2%) (Fig. 4-b).

The origin from the sternum generally extends to the level of the sternal angle and is fused with the origin of the *M. sternohyoideus* so that these two muscles cannot be separated, but in general, the origin of this muscle is located more laterally and its most outer edge (between the first and second ribs) is tendinous.

This muscle, like the *M. sternohyoideus*, has a tendinous in-

Fig. 4 Variations of origin of the m. sternohyoideus

a. (upper-ventral view)

b. (dorsal view)

Fig. 5 Situation of origin of m. sternohyoideus and its fusion to m. sternothyroideus (The muscles were turned down backward at the original portion)

scription near its origin. The state of fusion between the muscle bundles of each side and with the *M. sternohyoideus* has been described in the preceeding section (Fig. 5-a, b).

The insertion of this muscle in all cases is into the lateral half of the lower edge of the laminae of the thyroid cartilage but never extends to the oblique line.

In primates, the origin of this muscle may sometimes extend as far down as the level of the third costal cartilage as noted in Lemur (Murie & Mivart, Oishi), *Chiromys* (Zuckerkandl), *Macacus* (Oishi), etc., but generally it extends only as far as the level of the second costal cartilage as found in my cases of *Macaca cyclopis*. In man, like *Macaca cyclopis*, the origin usually is exclusively from the sternum (46.2%, Morishita), but although very infrequently in *Macaca cyclopis*, cases having, in addition to the muscle bundle from the sternum, the participation of a muscle bundle from the clavicle (21.2%) or from the rib (32.5%) are seen at a considerable frequency.

The insertion of this muscle in such lower monkey as *Prosimiae*, *Macacus*, *Semnopithecus*, etc. is generally the lower edge or the caudal side of the thyroid cartilage (Murie & Mivart, Oishi, Howell and Straus, Kohlbrügge) and the condition is likewise in *Macaca cyclopis*. However, there seem to be occasional cases of insertion into the lateral surface of the hyoid bone such as seen in common marmoset (Beattie) or the medial region of the thyroid cartilage as in *Macacus rhesus* (Kurz). Furthermore, in gibbons and chimpanzee, it separates into two parts, one of which ends at the cranial portion of the oblique line while the other terminates at the inferior tubercle (Kohlbrügge, Oishi, and others) and in gorilla, it inserts at the oblique line while it likewise ends generally at the oblique line in man. In view of these findings, it is felt that the level of insertion may become higher with advance in evolution.

The tendinous inscription, found in all of my cases of *Macaca cyclopis*, is said to be found regularly in primates except for its occasional absence in gibbons (Oishi) and chimpanzee (Oishi, Champney). It is frequently seen in man also, but the frequency is much less than in primates (65%, Adachi).

In primates, such fusion of this muscle with its companion on the opposite side and the fusion with the *M. sternohyoideus*, as described in the preceeding section on the *M. sternohyoideus*, is as

a rule found and the extent and condition of fusion is generally the same as my findings in *Macaca cyclopis*.

3. *M. omohyoideus*

This narrow muscle which runs obliquely in the middle layer of the lateral neck increases in width during its course in the lateral neck so that the belly is of considerable size.

It arises tendinously from the middle part of the upper edge of the scapula (a little to the medial side of the incisura scapulae) and runs obliquely beneath the *M. trapezius*, *M. sternomastoideus*, *M. cleidomastoideus* and the *M. cleidoccipitalis* to the lateral margin of the *M. sternohyoideus* with which it fuses and inserts by a narrow tendon into the body of the hyoid bone (lateral portion of the lower margin of the hyoid).

At the origin, it is fused with the *M. subscapularis* and *M. supraspinatus*. An intermediate tendon is not noted in the belly.

As a variation, separation of the belly into two parts was seen in 1 case (No. 9, male, right side). In other words, after arising by tendon, the belly separated into two parts which overlapped each other and fused again near its insertion. Furthermore, one of these two parts was joined by a muscle bundle from the *M. sternothyreoideus* (Fig. 6). In this case, the nerve supply was by a branch from the *Ansa nervi hypoglossi* formed by C_2 , C_3 and C_4 .

This muscle was present in all cases of my *Macaca cyclopis*, but it is reported to be occasionally absent in *Semnopithecus* (Kohlbrügge), orang-outan (Bischoff) and in man.

The origin of this muscle in *Macaca cyclopis* was away from the incisura scapulae and was from the scapular plate. This finding is the same as that reported

Fig. 6 Variation of the *m. omohyoideus*

for Lemur (Murie & Mivart), Chiromys (Zuckerkandl), *Macacus rhesus* (Howell and Straus, Oishi) and *Semnopithecus* (Oishi) and indicates that the origin is situated more medial than in *Lemur macaco* (Oishi), Common marmoset (Beattie), *Macacus rhesus* (Kurz), *Hylobates spec.* (Oishi), gorilla (Raven), chimpanzee (Sonntag, Champneys) or man.

Furthermore, in man there frequently is origin from the clavicle and such mention has been made in gibbons (Kohlbrügge), chimpanzee (Gratiolet, Michaelis), etc., but no case was found among my *Macaca cyclopis*.

The intermediate tendon is reported to be absent in Prosimiae except *Tarsius* (Eisler), Lemur (Oishi), *Chylomis* (Zuckerkandl), Common marmoset (Beattie), *Macacus*, *Cynocephalus*, *Cercopithecus* (Vrolik, Kurz, Howell and Straus, Oishi), gorilla (Bischoff, Raven) and in chimpanzee (Michaelis, Sonntag, Champneys) so that it may be assumed that in general the intermediate tendon is absent in primates. However, the intermediate tendon has been noted in orang-outan by Testut, in chimpanzee by Oishi, in *Semnopithecus* by Parsons, Eisler and Oishi, and in *Macacus* by Macalister and Testut. In man, the intermediate tendon is usually found (Japanese adult 88.4%, newborn 75%, Morishita).

Loth has classified this condition into 6 types and all cases of *Macaca cyclopis* would correspond to his type I (no intermediate tendon). The frequency of this type in man has been reported to be 1.9% in Chinese (Wagenseil), 3% in Poles (Loth), 5.5% in Negroes (Loth), 11.6% in Japanese adults, 25% in newborn (Morishita), and 24% in fetus (Yonekura).

The insertion in Simiae is reported to be usually by a narrow tendon into the body of the hyoid bone at the lateral margin of the *M. sternohyoideus*. The condition in *Macaca cyclopis* is similar and the separation of the insertion into two parts such as found in *Hylobates spec.* by Oishi was not noted.

Loth has classified the form of this muscle in man into 5 types according to the state of origin of this muscle and whether the intermediate tendon is present or not, but the condition in *Macaca cyclopis* was of only 1 type with no differentiation into various types. That is, *Macaca cyclopis* correspond to only type 4 of Loth which is rarely found in man (the cleidohyoid bundle is absent and only the true omohyoideus is present although the intermediate tendon is absent).

Separation or duplication of this muscle may be seen in man as a variation, but there is no mention of such a condition in primates except for the chimpanzee of Gratiolet in which the inferior belly separated into two parts that insert into two separate areas.

The variation seen among my cases should be regarded as separation rather than duplication of this muscle.

Nerve supply:

The nerve supply to the above 3 muscles is by a branch from the Ansa hypoglossi.

The Ansa hypoglossi in *Macaca cyclopis* is formed by the union of the R. descendens n. hypoglossi and the upper cervical nerves, but most frequent is the participation by C₂ and C₃ (77.5%). There also are other cases in which C₄ also contributes (15%) as well as some instances in which only C₃ participates (7.5%).

4. M. thyreoideoideus

This muscle is located between the thyroid cartilage and the hyoid bone, but since these two in *Macaca cyclopis* are located so that they generally overlap each other, the shape of this muscle is very short and broad.

This muscle arises, adjacent to the insertion of the M. sternothyreoideus, by muscle from the lower margin of each lamina of the thyroid cartilage and the inferior thyroid tubercle.

Although this muscle and the M. sternothyreoideus are slightly separated so that the thyroid cartilage clearly show in-between at a considerable frequency (20%), both muscles are adjacent in the greater majority. However, there is no communication of muscle fibers between them.

This muscle runs in radial fashion cranialward and separates into the deep and superficial layers. The deep layer inserts into the anterior lower margin of the greater cornu of the hyoid bone while the superficial layer continues with the muscle bundle of the M. hyoglossus which arises from the greater cornu of the hyoid bone. (Fig. 3-a, b)

Nerve supply:

The innervation is by the second branch from the N. hypoglossus in all cases.

With respect to the origin of this muscle, Oishi reports that the origin is from the superior region of the inferior thyroid tubercle and the caudal side of the lamina of the thyroid cartilage in *Lemur macaco*, from the triangle formed by the caudal margin of the lamina of the thyroid cartilage and the caudal region of the oblique line in *Cebus capcibus*, *Macacus rhesus* and *Semnopithecus*, from the inferior tubercle and the caudal side of the oblique line in *Hylobates spec.*, whereas it is from the dorso-caudal side of the lamina of the thyroid cartilage in chimpanzee. In contrast to this, Murie & Mivart report it to be from the most posterior part of the thyroid cartilage while it has been reported to be from the oblique line in *Macacus rhesus* of Kurz, in gorilla of Raven and in chimpanzee of Champneys so that in general the site of origin appears to move upward and backwards with advance from lower monkey to higher apes.

In many reports, the insertion of this muscle in primates is said to be the body and greater cornu of the hyoid bone, but there is mention of insertion into only the body of the hyoid bone (common marmoset of Beattie, rhesus monkey of Howell and Straus, gibbons of Oishi) or only into the greater cornu (*Lemur* of Murie & Mivart, *Semnopithecus* of Kohlbrügge).

In my cases of *Macaca cyclopis*, this muscle prior to its insertion, separated into superficial and deep layers. The muscle fibers of the superficial layer is directly continuous with the *M. hyoglossus* to present the condition of the so-called *M. thyreoglossus*, but since only the superficial layer is involved it cannot be said to be a complete *M. thyreoglossus*.

Such a condition has been reported previously by Oishi in *Macacus rhesus*, but in his case the muscle bundles of the deep layers continued with the *M. hyopharyngeus* as in *Macacus fascicularis* (Bernstein). In *Macaca cyclopis*, however, such a relation could not be found. Furthermore, it was simply adjacent to the *M. sternothyreoideus*, but in chimpanzee both muscles are said to be intertwined or connected (Oishi).

Summary

1. *M. sternohyoideus*

This muscle usually, arises muscularly from the dorsal surface of the upper margin of the manubrium sterni and inserts by muscle into the lower margin of the body of the hyoid bone. However,

there may be cases in which the site of origin may extend as far as the sternal end of the clavicle or the sterno-costal junction of the first rib.

In addition to fusion in the area from the origin to the upper margin of the sternum and in the area of the tendinous inscription that is present a short distance from the upper margin of the sternum, there may even be communication between the muscle bundle of each side.

2. *M. sternothyreoideus*

This muscle which is located on top of and adhered to the origin of the *M. sternohyoideus* usually arises from the posterior surface of the manubrium sterni. As it ascends, the muscles on each side separate from each other and insert muscularly into the lateral half of the lower margin of the laminae of the thyroid cartilage. Furthermore, a tendinous inscription may be found a short distance above the upper edge of the manubrium sterni.

3. *M. omohyoideus*

This muscle arises by tendon from the middle of the upper margin of the scapula (a short distance medial to the incisura scapulae). One part of the muscle bundle fuses with the muscle bundle of the *M. sternohyoideus* while one portion becomes tendinous and fuses with the outer edge of that muscle to insert into the lateral part of the lower edge of the body of the hyoid bone. There is no intermediate tendon such as found in man.

4. *M. thyrohyoideus*

This muscle arises muscularly from the laminae of the thyroid cartilage and the thyroid tubercle. It usually is adjacent to the *M. sternothyreoideus*, but there is no communication of muscle fibers. During its course upward, it separates into the superficial and deep layers. The deep layer inserts into the anterior lower edge of the greater cornu of the hyoid bone while the superficial layer continues with the muscle bundle of origin of the *M. hyoglossus*.

5. *Nerve supply*

With regard to the nerve supply, the *M. sternohyoideus*, *M. sternothyreoideus* and *M. omohyoideus* are innervated by branches from the Ansa nervi hypoglossi which generally is associated with and formed by C₂ and C₃. In addition, there may be cases in which

there may be the addition of C_4 to the composition of this Ansa hypoglossi, or others in which it is formed only by C_3 or by C_2 . The M. thyreochoideus is supplied by a branch from the N. hypoglossus (XII).

References

1. Adachi, B., 1910. Beiträge zur Anatomie der Japaner (XII. Die Statistik der Muskelvarietäten). Zeit. f. Morph. u. Anthropol., 12, 261-312.
2. Beattie, J., 1927. The Anatomy of the Common Marmoset. Proc. Zool. Soc., London, 593-718.
3. Bernstein, H., 1928. Über das Stimmorgan der Primaten. Abh. Schenkbn. naturf. Ges., 38, 105-128.
4. Champneys, F., 1871. On the Muscles and Nerves of a Chimpanzee (*Troglodytes niger*) and a *Cynocephalus anubis*. J. Anat., London, 6, 176-211.
5. Chapman, H. C., 1879. On the Structure of the Chimpanzee. Proc. Ac. Nat. Sc., Philadelphia, 52-64.
6. do., 1880. On the Structure of the Orang-Utan. Proc. Ac. Nat. Sc., Philadelphia., 160-175.
7. do., 1900. Observation upon the Anatomy of *Hylobates leuciscus* and *Chiromys madagascariensis*. Proc. Ac. Nat. Sc., Philadelphia, 414-423.
8. Eckstein, A., 1912. Bemerkungen über das Muskelsystem eines Negerfoetus. Anat. Anz., 41, 334-340.
9. Eisler, P., 1912, Die Muskeln des Stammes. Gustav Fischer, Jena.
10. Fedoroff, D. N., 1927. Zur Morphologie der Muskelvarietäten des lateralen Gebietes des Halses. Anat. Anz., 62, 338-346.
11. Fick, R., 1895. Vergleichend anatomische Studien an einem erwachsenen Orang-Utan. Arch. f. Anat. u. Physiol. 13-100
12. do., 1895. Beobachtungen an zweiten erwachsenen Orang-Utan und einem Schimpansen. Arch. f. Anat. u. Physiol., 289-318
13. do., 1925. Beobachtungen an der Muskeln einiger Schimpansen. Z. Anat. Entw. Gesch., 76, 127-141.
14. Gratiolet, L. P., et Alix, P. H., 1866. Recherches sur l'anatomie du *Troglodytes aubryi*, chimpanzé d'une espèce nouvelle. Nouv. Arch. Mus. Hist. Nat. Paris, 2, 1-264.
15. Howell and Straus, 1961. In "The Anatomy of the Rhesus Monkey" ed. by Hartman & Straus. Hafner, New York.
16. Kohlbrügge, J. H. F., 1897. Muskeln und periphere Nerven der Primaten, mit besonderer Berücksichtigung ihrer Anomalien. Verh. Akad. Wet., Amst., Sect. 2, 5, 1-246
17. Kurz, E., 1918. Muskeln und Nerven der Hals-und Brust-Schultergegend von *Macacus rhesus*. Arch. Anat. u. Phys., Anat. Abt., 42, 225-241.
18. Loth, E., 1912. Beiträge zur Anatomie der Nagerweichteile (Muskelsystem). Stud. n. Forsch. d. Menschen-und Völkerkunde, 9, Stuttgart.
19. do., 1931. Anthropologie des parties molles. Masson, Paris.
20. Macalister, A., 1871. On the some points of the chimpanzee and other primates. Ann. Mag. nat. Hist., 7, 341-351.
21. Michaelis, P., 1903. Beiträge zur vergleichenden Myologie des *Cynocephalus babium*, *Simia satyras*, *Troglodytes niger*. Arch. f. Anat. u. Phys. Anat. Abt.,

- 27, 205-256.
22. Morishita, T., 1947. Studies on the Muscular System. (Especially comparison between newborn and adult). Kyudai Kaibo Gyoseki Nenpo, 1, 1-32 (in Japanese)
 23. Murie, J. and Mivart, St. G., 1866. On the Anatomy of the Lemuroidea. Trans. Zool. Soc. Lond., 7, 1-113.
 24. Oishi, K., 1941. Studies on the infrahyoid-, laryngeal-, pharyngeal, and lingual-muscles. Tokyo Igk. Z., 55, 667-712 (in Japanese)
 25. Parson, F. G., 1898. The muscles of mammals, with special relation to human myologie. (Lecture-I), J. Anat. London, 32, 428-450.
 26. Raven, H. C., 1950. The Anatomy of the Gorilla. Columbia Univ. Press, New York.
 27. Sonntag, F. F., 1923. On the Anatomy, Physiology and Pathology of the Chimpanzee. Proc. Zool. Soc. London, 27, 323-429.
 28. Testut, L., 1884, Les anomalies musculaires chez l'homme. Schleicher, Paris
 29. Uematsu, K., 1930. Plexus u. Nn. hypoglossi in Mammals. Kaibo Z., 3, 73-83. (in Japanese)
 30. Vrolik, W., 1841. Recherches l'anatomic comparée sur le chimpansé. Johannes Müller, Amsterdam.
 31. Wagenseil, F., 1937. Untersuchungen über die Muskulatur der Chinesen. Z. f. Morph. u. Anthropol. 36, 110-127.
 32. Yamada, F., 1934. Some variations of the infrahyoid muscle and insertion of trapezius into the clavicle of Japanese foetus and newborns. Kaibo Z., 7, 337-347. (in Japanese)
 33. Yonekura, S., 1954. A study of the muscles of the neck, chest, abdomen and back in Japanese fetuses. Igaku Kenkyu, 24, 74-170. (in Japanese)
 34. Zunker andl, E., 1900. Zur Anatomie von Chiromys madagascariensis. Denkschr. D. Kais. Akad. d. Wissensch., Wien, Math.-Naturw. 68, 89-200.