Anatomical Aspects of the Masticatory Muscles of the Tufted Capuchin (*Cebus apella*)

By

MIGUEL C. MADEIRA and J. AMÉRICO DE OLIVEIRA

Department of Morphology, School of Dentistry, State University Julio de Mesquita Filho, 16100 Araçatuba, São Paulo, Brazil

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**Summary.** The description of the macroscopic structure of the masticatory muscles is based upon the dissection of 26 adult and juvenile tufted capuchin monkeys (*Cebus apella*) of both sexes.

A detailed description of the temporal, masseter and medial and lateral pterygoid muscles on each side of the head is given. Not only the general shape, origin and insertion are described, but also the architectonic organization, i.e. the stratiform disposition of the muscle parts. Anatomical variations in each sex or age appear to be few and unimportant.

Anatomical aspects are found to be essentially similar to those found in other primates including man; however some characteristic differences do exist and deserve special comment.

**Introduction**

As the use of primates in biomedical research laboratories has rapidly increased, more information on their anatomy is often required.

Anatomical descriptions on the platyrhine monkeys are noticeably lacking. *Cebus* is one of the more neglected genus in anatomical investigation. In examining the literature we found little information (Toldt, 1905; Starck, 1933; Zlabek, 1936; Hill, 1964; Gaspard, 1972; Gaspard *et al.*, 1973a; Matheus *et al.*, 1974) on its masticatory muscles. The studies available have been based upon a small number of specimens and are superficial in their coverage.

The purpose of the present study was the determination of the standard anatomical condition of the muscles of mastication in the *Cebus apella*.

**Materials and Methods**

The following descriptions are based upon the bilateral dissection of 26 male and female, adult and juvenile tufted or brown capuchin monkeys (*Cebus apella*) captured in the State of São Paulo, Brazil.

Direct dissection was used for the description of the muscles of mastication. The minute portions were examined with the use of a magnifying lens. The zygomatic arch was resected as necessary to
analyse the temporal muscle.

The terms of the muscular layers were adopted after the old usage of various authors with a slight modification.

**Observations**

*Temporal muscle* It was a wide-spread muscle, anteriorly thick and posteriorly thin, which filled a large area corresponding to its origin, the temporal fossa. In older individuals of both sexes the temporal line moved toward the median plane, thus increasing the temporal fossa. In some of them a sharp sagittal crest could be seen as a result of this displacement.

The muscular fibers arose from the floor of the temporal fossa, except from that part of the zygomatic bone behind the orbit (Figs. 1, 2). Strong tendinous and muscular fasciculi attached to the infratemporal ridge that formed the inferior boundary of the temporal fossa. The fibers also took origin on the inner surface of the heavy temporal fascia, not including its antero-inferior angle, close to the zygomatic arch, where a layer of fat separated the fascia and the muscle. Some fibers also invaded the medial aspect of the zygomatic arch.

From this extensive origin the fibers ran deep into the zygomatic arch to insert on the margins and medial surface of the coronoid process, extending along the mandibular ramus down to the posterior end of the oblique line (Fig. 1). The anterior fibers were vertical, but posteriorly they became increasingly

**Abbreviations**

- **M1 and M2**: first and second laminae, respectively, of the superficial portion of the masseter muscle.
- **M3**: intermediate portion of the masseter muscle.
- **M4 and M6**: anterior and posterior laminae, respectively, of the deep portion of the masseter muscle.
- **PL1 and PL2**: superior and inferior portions, respectively, of the lateral pterygoid muscle.
- **PM1, PM6 and PM5**: anterior, intermediate and posterior laminae, respectively, of the medial pterygoid muscle.
- **PM4, PM5 and PM6**: superficial, intermediate and deep laminae, respectively, of the deep portion of the medial pterygoid muscle.
- **T1**: first lamina of the temporal muscle.
- **T2, T3 and T4**: superficial, intermediate (tendon) and deep portions, respectively, of the temporal muscle.
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oblique to finally reach a horizontal direction (Fig. 2).

The dissection revealed a stratiform disposition of the muscle parts. The

most superficial bundle (first lamina) was small and spread over the antero-inferior part of the temporal, making a semicircular plate partially covered by the masseter muscle (Fig. 2). Arising from the superior part of the temporal surface of the zygomatic bone and from the proper fibers of the temporal muscle close to the zygomatic bone, this bundle
descended in a downward direction to insert through a long but weak tendon on a tubercle placed ahead of the masseteric fossa (Fig. 3).

The reflection of the first lamina showed a heavy tendon which inserted along the coronoid process and the anterior border of the ramus, extending to the retromolar area. This was a central plate within the sagittal plane of the muscle that divided the remainder fibers into two fleshy portions: a large superficial and a smaller deep one. Both portions attached to the central tendon as a bipennate muscle.

The superficial portion terminated on the margins of the coronoid process and part of its lateral aspect. As reflected, the tendon, which was considered the intermediate portion, could be shown entirely (Fig. 4). The older the animal, the larger the tendon. The removal of the tendon discovered the deep portion (Fig. 3), which inserted on the entire medial surface of the coronoid process.

**Masseter muscle** This muscle was shorter but thicker than the temporal. It arose from the lower edge of the zygomatic arch and passed downward and backward to insert into the entire lateral side of the mandibular ramus below the base of the coronoid and the condylar processes (Figs. 1, 2).

The so-called superficial and deep portions could be easily recognized. Careful dissection showed that the muscle was actually formed by three portions, the first of which split into two laminae (Fig. 4). The two laminae arose as a single mass from the anterior three fourths of the zygomatic arch, i.e. from the zygomatic process of the maxilla to the zygomaticotemporal suture. They inserted on two separate curved lines accompanying the angle of the mandible; the marginal line for the first lamina was longer and rougher than that for the second lamina. While the first lamina was tendinous at the origin, the second one was muscular; the inverse was observed at the insertion (figures 2, 4). The whole superficial portion bulged out anteriorly so that its rostral margin covered the second molar tooth.

The intermediate portion was organized into a thin but resistant sheet, which firmly adhered to the zygomatic arch by tendinous fibers, medially to the superficial portion (Fig. 5). Its muscular fibers inserted into the masseteric fossa, a shallow concavity in the center of the ramus.

All these three preceding oblique laminae were separated from the deep portion by a sagittal cleft.

The deep portion, which also included two laminae, was different from the others for being fleshy, short, and vertical. The anterior and posterior laminae were separated by the masseteric nerve (Fig. 6). The origin included the rear half of the zygomatic arch, reaching the temporomandibular joint posteriorly. The superior fourth of the lateral side of the ramus provided the area for insertion.

The so-called maxillomandibular or zygomaticomandibular muscle, extending from a restricted area on the medial aspect of the zygomatic arch to the ramus immediately below the coronoid process, was not identified as a true separate muscle. It appeared to be the continuation of the deep portion of the masseter, and innervated by the masseteric nerve. Its upper fibers were also continuous with the superficial fibers of the temporal muscle. This fleshy, short muscle had mainly vertical fibers downwards and slightly oblique backwards.

**Medial pterygoid muscle** This muscle was formed by six layers that arose from the pterygoid fossa, between the
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Figs. 7-11. Stratiform disposition (laminar pattern) of the medial pterygoid muscle.

medial and lateral pterygoid plates. Its bulk filled the entire depth of the pterygoid fossa. Additional fibers came from the piramidal process of the palatine bone, the pterygoid hamulus, and a line 1 mm wide on the lateral surface of the lateral plate close to the inferior border. The insertion on a well marked concave area of the medial face of the mandibular ramus was bound below by the mandibular
basis, behind by the posterior border of the ramus, above by the mandibular foramen, and in front by the mylohyoid sulcus (Fig. 1). One to three bony ridges of variable development were present within the area and corresponded to the attachment of a like number of intramuscular tendinous strands. The front border of the medial pterygoid muscle extended beyond the field of insertion of the mylohyoid muscle thus covering its posterior fibers.

The masseter muscle was highly developed, wrapping the mandibular angle and rejoining the bundles of the medial pterygoid through a fibrous raphe on the internal face of the mandible. Exchanges between the masseteric and pterygoid bundles were never observed.

The medial pterygoid muscle consisted of a laminar pattern arranged into two portions included three laminae each. The thin superficial portion arose from both the pterygoid hamulus and the piramidal process, descended lateralward and backward to terminate on a line which followed along the mandibular angle and extended anteriorly toward the mylohyoid sulcus. It was formed by three laminae: anterior, intermediate, and posterior (Figs. 7, 8).

As the superficial portion was severed and stripped aside, the deep portion was exposed (Fig. 9). It arose from the depth of the pterygoid fossa, terminating on the medial surface of the ramus, bounded anteriorly and inferiorly by the insertion of the superficial portion. The three musculo-tendinous laminae of the deep portion was called superficial, intermediate, and deep (Figs. 9, 10, 11). The third or deep lamina overrode the area of origin and appeared in the infratemporal fossa attached to the inferior border of the lateral plate and part of its lateral surface next to the border.

Lateral pterygoid muscle This small muscle was shaped like a cone the base of which corresponded to the infratemporal origin and its truncated apex to the insertion on the mandible. At first sight it seemed to be composed by two bellies or portions easily identifiable by the presence of a vasculo-nervous bundle between them and by the different direction and insertion of their fibers (Fig. 12).

The superior portion, much smaller than the inferior portion, arose from the infratemporal surface of the sphenoid bone (Fig. 1). The upper edge of this belly was separated from the temporal muscle by the infratemporal crest. From the origin it extended further posteriorly and laterally in an almost horizontal plane and inserted at a small superior area of the pterygoid fovea of the mandible (Fig. 1) and at the anterior border of the articular disc.

Minute dissection showed that the large inferior portion was in most of cases composed of two muscular bundles.
Fig. 13: Superior view of the mandible, showing the insertion of the lateral pterygoid muscle.

The upper one arose from an area midway up the height of the lateral surface of the lateral pterygoid plate and the lower bundle occupied the inferior half of the same plate. Both bundles narrowed latero-superiorly to join the fibers of the superior portion and to attach to the pterygoid fovea through short tendons. But the lower bundle, besides inserting on the fovea, had its medial short fibers anchoring to the medial pole of the condyle and to the medial part of both the capsule and the disc of the temporomandibular joint (Fig. 13).

Important anatomical variations were never observed. The morphological characteristics of the studied muscles did not appear to vary with side of body. Of course, differences of development or growth existed between adult and juvenile monkeys. The males also showed more developed muscles than the females.

Discussion

The results are overall in accordance with the older descriptive literature on the subject. Although the masticatory muscles have an architectural organization and a shape basically the same in all primates, there are some differences concerning the tufted capuchin.

The sagittal crest upon the cranium is a feature of the Cebus apella. It is not encountered in C. capucinus, C. albifrons, and C. griseus, in which the temporal muscles never extended to the vertex (Hill, 1964).

The central tendon of the temporal muscle is characteristic of the mammals (Laison and Lautrou, 1975). It has been described in other species of primates (Starck, 1933; Imai et al., 1963; Schön, 1968) as well as in man (Sicher and Du Brul, 1975) and appeared to be similar in all cases.

The first lamina of the temporal muscle, which has also been called pars supra-zygomatica (Schumacher, 1961) or zygomaticomandibularis muscle (Yoshikawa and Suzuki, 1962; Gaspard, 1972), is similar to that of catarrhines (Gaspard, 1972; Sanefuji, 1972). It seems to be reduced in the Cebus in comparison to that of the carnivores (Gaspard et al., 1977). In the human it is extremely reduced (Gaspard et al., 1973b). Imai et al. (1963) made a severe criticism of the usage of zygomaticomandibularis as a term to define the most superficial portion of the temporal muscle (innervated by a deep temporal nerve). It seems that it is a really inadequate term since that bundle is not a separate muscle and there is already a so-called zygomaticomandibular muscle interposed between the zygomatic arch and the mandibular ramus (see below); moreover in some species the bundle does not arise
The shape and architecture of the masseter muscle of *Cebus* agree in almost every detail with those of rhesus (Howell and Strauss, 1961; Schwartz and Huelke, 1963; Gaspard et al., 1973a) and other primates (Zlabek, 1936; Gaspard et al., 1973a). However the superficial masseter of catarrhines originates from a large line along the zygomatic arch (Zlabek, 1936), and in the *Cebus* it concentrates on a restricted area of the zygomatic bone which makes it more inclined.

The lamination of the masseter of primates was extensively done by several authors with some differences in the refinement of the technique. The observations of Schumacher (1961; 1963), Yoshikawa and Suzuki (1962; 1965; 1969), Gaspard et al. (1973a), and Matheus et al. (1974) hardly differed from our description. Sanefuji (1972) reports two laminae for the intermediate portion in *Macaca cyclopis*. We also observed a case like that as a variation.

Disagreement exists about the recognition of a separate muscle between the masseter and the temporal, the zygomaticomandibular (maxillomandibular). Starck (1933) and Hill (1964) found it in every species of platyrrhines, with exception of the *Lagothrix*. Schön (1968) did not identify it as a separate bundle in *Alouatta*. Toldt (1905) and Schumacher (1961) regard this muscle as a part of the temporal muscle, but most of authors, including us, consider it a separate, independent part of the masseter, innervated by the masseteric nerve.

The architecture of the medial pterygoid muscle appears to be more complicated than hitherto described. At the mandibular level it consists of six plates superposed with slight different vectors, which give some independence to each plate and also strengthen the whole muscle. Our description agrees with those of Schumacher (1961) and Gaspard et al. (1973c) who studied this muscle in genus *Cebus*. The morphological traits were observed by these authors as being about the same among macaques, cynomorphs, platyrrhines, and anthropomorphs.

As compared to man, the lateral pterygoid muscle in monkeys is quite reduced in volume, almost like that of carnivores. But its anatomy and relationship rather resemble that of the human. The two main bellies of the lateral pterygoid are a general feature of primates. The division of the inferior belly in a few cases is also reported by Nagashima et al. (1975) in *Macaca cyclopis*. Electromyographically, McNamara (1972; 1973) and Grant (1973) distinguish two distinct functional patterns for the two muscular bellies in *Macaca mulatta* and in man. The inferior belly, which is approximately three times larger than the superior, acts in the opening and the protrusive movements of the mandible. The superior belly acts in positioning and stabilizing the articular disc (and condyle) during the closing movements of the mandible; it is not active during the opening movements. Minute dissection showed that a bundle of fibers of the inferior belly also attaches to the disc. This condition coincides with the description of Landucci and Ramalho (1974) in adult human material.

Balance or stabilization of the disc during opening movements appears to be assisted by these fibers of the inferior belly of the lateral pterygoid muscle which insert on the disc.

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