The M. Masseter of the Formosan Monkey

By

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Introduction

Since the first study by Toldt (1904) the M. masseter of primates in particular has been studied by many investigators including Bluntschli (1929), Stark (1933), Yoshikawa et al. (1960-69) and Imai (1963).

These studies, however, disagree considerably in the findings on the composition of this muscle. There also are divergent views on the presence of the M. zygomaticomandibularis and M. maxillomandibularis, which were regarded as the improper masseter group by Yoshikawa et al. and on whether these should be considered part of the M. masseter or part of the M. temporalis.

An attempt was made to clarify these questions by a statistical morphological study of the M. masseter in a comparatively large number of cases of Macaca cyclopis and by comparison of the findings with those in other primates.

Material and Method

The Satoh collection of adult Formosan monkey (Macaca cyclopis) was used for a study of the Mm. masticatorii (9 male and 16 female cases, total 25 cases, 50 sides). These specimens stored at the First Department of Anatomy, Nagasaki University Faculty of Medicine, had been fixed with 10% formalin solution injected into the blood vessels and then preserved in this solution of the same concentration.

Inspection was done with the aid of dissection tweezers and magnifying lenses with illumination attachment, and the method of Yoshikawa et al. was carefully followed in which the tendon beneath the fascia is confirmed by incising and stripping away the fascia along the course of the tendon. The arcus zygomaticus, ramus man-
dibulae, etc. were resected as necessary to examine the origin and insertion of the muscle, the muscular layers, direction of muscle bundles and nerve supply.

Findings

As in man, the M. masseter of Macaca cyclopis, together with the M. temporalis, M. pterygoideus internus and M. pterygoideus externus, forms the Mm. masticatorii. However, the M. masseter, which may be separated grossly into the superficial and deep layers, can be completely exposed by removing the facial cutaneous muscles and the parotid gland. The muscle bundles in the superficial layer of the M. masseter arise from the anterior half of the arcus zygomaticus partially by tendon and partially by muscle, and insert by muscle into the area about the angulus mandibulae. The deep layer arises muscularily from the posterior half of the arcus zygomaticus, and inserts into the lateral surface of the ramus mandibulae. Further subdivision of this muscle is possible as follows:

I. M. masseter superficialis
   1) M. masseter superficialis lamina prima
   2) M. masseter superficialis lamina secunda

II. M. masseter intermedius
   1) M. masseter intermedius lamina prima
   2) M. masseter intermedius lamina secunda

III. M. masseter profundus
   1) M. masseter profundus lamina prima
   2) M. masseter profundus lamina secunda

IV. M. masseter profundissimus

I. M. masseter superficialis

The muscle bundles which form the superficial layer of the M. masseter may be subdivided into the following two layers.

1) M. masseter superficialis lamina prima (figure 1-a)

   This muscle layer arises tendinously from the anterior half of the arcus zygomaticus and inserts muscularily into the ramus mandibulae in the area about the angulus mandibulae.

   At the insertion of this muscle bundle, there frequently is found the so-called pars reflexa (Tullberg), which extends beyond the basis mandibulae to the inner side (left 19/25, right 19/25), and in the region of the angulus mandibulae the muscle bundle overlaps the M. pterygoideus externus at the inner side of the ramus mandibulae.
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Furthermore, the anterior edge of the insertion, that is, the angulus antero-inferior M. masseter in a slightly greater majority of cases extends beyond the basis mandibulae to insert into the inner surface of the mandible.

2) M. masseter superficialis lamina secunda (figure 1-b)
This muscle layer, like the M. masseter superficialis lamina prima, arises by muscle from the anterior half of the arcus zygomaticus,
but the area of origin is greater and extends farther back. Thus, the posterior half of this muscle layer is exposed while the remaining larger portion is covered by the lamina prima, and it is located on the lower layer. The insertion is by tendon into the lateral surface of the ramus mandibulae slightly above the line of insertion of the abovementioned lamina prima.

II. M. masseter intermedius

1) M. masseter intermedius lamina prima (figure 1-c)

This muscle layer, located beneath the M. masseter superficialis lamina secunda, arises tendinously from the lower edge of the arcus zygomaticus. This muscle bundle courses obliquely backward and downward to insert muscularly into the lateral surface of the ramus mandibulae, but due to the wide area of insertion, this muscle as a whole presents a trapezoid shape. The N. massetericus passes between the anterior edge of this muscle and the deepest part of the M. masseter (the part corresponding to the so-called M. zygomatico-mandibularis of Toldt). Examination of the insertion revealed that the upper margin of the insertion extends to the lower edge of the fossa masseterica of the ramus mandibulae while the lower margin is almost parallel with the basis mandibulae and adjacent to the line of insertion of the M. masseter superficialis lamina secunda.
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The anterior edge of the M. masseter intermedius is usually separated from the M. masseter profundissimus by the branch of the N. massetericus supplying the M. masseter superficialis. When this branch of the N. massetericus is absent, only the direction of the muscle bundles may be used as the indicator of the separation of these two. At the posterior edge, the direction of the muscle bundle is entirely different from that of the M. masseter profundus lamina prima and can also be readily identified by the considerable amount of connective tissue.

2) *M. masseter intermedius lamina secunda* (figure 1-d)

This muscle bundle beneath the M. masseter intermedius lamina prima presents the shape of a trapezium or parallelogram. This muscle layer arises by a mixture of muscle and tendon from the lower edge of the arcus zygomaticus and runs almost vertically or slightly obliquely downward and forward. The anterior half of this muscle inserts muscularly into the lower edge of the fossa masseterica of the ramus mandibulae. Behind and continuous with this insertion of the anterior half there is the muscular insertion of the posterior half onto the tendon of insertion of the M. masseter profundus lamina prima.

This muscle had been included as part of the M. masseter in-
maseter profundus for the following reasons. The direction of the muscle bundle of this muscle differs only slightly from that of the M. masseter intermedius lamina prima, and its area of origin as well as its state of insertion by muscle is almost the same as that of the M. masseter intermedius lamina prima. In contrast to this, the direction of its muscle bundle differs entirely from that of the M. masseter profundus and the condition of its insertion is entirely different from that of the M. masseter profundus lamina prima which is by tendon.

However, since the direction of the muscle bundle, condition of origin and insertion, etc. of this muscle layer are almost the same as the M. masseter intermedius lamina prima as mentioned above and the separation of these two requires considerable force, it perhaps may have been more appropriate not to have considered it an independent muscle layer.

There was one case in which a muscle layer corresponding to this could not be identified.

**III. M. masseter profundus**

1) *M. masseter profundus lamina prima* (figure 1-e)

When the belly of the above-mentioned M. masseter intermedius lamina secunda is severed and stripped aside, the M. masseter profundus lamina prima and the anterior half of the underlying M.
The origin of this muscle layer is muscularly from the lower surface of approximately the posterior two thirds of the arcus zygomaticus. That is the origin involves an area extending from the sutura frontozygomatica to the root of the arcus zygomaticus and capsula articularis mandibulae. Although it is wide at the origin, this muscle gradually decreases in width as it descends. It becomes tendinous at about the middle of the belly and inserts by tendon into the posterior half of the fossa maseterica of the ramus mandibulae.

(Variations)

Two cases were found which seemed to show variations in the condition of this muscle.

(1) Case number 2, left side (figure 2-a)

On the lateral side of the M. masseter profundus lamina prima was seen a fusiform muscle which had localized tendinous origin from the vicinity of the lower edge of the sutura frontozygomatica of the arcus zygomaticus, and tendinous insertion into the fossa massterica of the ramus mandibulae. When the belly of this muscle was incised, it could be easily separated from the M. masseter profundus lamina prima.
Although it could not be confirmed that the nerve supply is by a branch of the N. massetericus, this muscle bundle was considered to be a variation of the M. masseter profundus lamina prima in view of the relation in the position of its origin and insertion.

(2) Case number 62, right side (figure 2-b)

A slender muscle was seen located between the M. masseter profundus lamina prima and the surface of the M. masseter profundus-simus. Its origin was muscularly from a narrow area on the lower edge of the central part of the arcus zygomaticus. The muscle bundle ran downward and backward to insert tendinously into a trapezoid field of insertion below the fossa massterica of the ramus mandibulae, that is, behind and below the insertion of the M. mas- sester profundus lamina prima.

The M. masseter intermedius lamina secunda such as noted in other cases was not present in this case.

2) M. masseter profundus lamina secunda (figure 1-f)

Cutting the belly of the M. masseter profundus lamina prima reaches the tendon of origin of the M. masseter profundus lamina secunda, and by stripping away this overlying layer along the course of this tendon the entire muscle is exposed.

This muscle layer arises tendinously from the lower surface of the posterior half of the arcus zygomaticus. This muscle layer is trapezoid in shape being wider at the origin than at the insertion.
It changes to muscle at about the middle portion and inserts muscu-
larly into a triangular field of insertion on the fossa masseterica.
This field of insertion is adjacent to the field of insertion of the M.
masseter profundissimus. This muscle and the M. masseter profun-
dissimus appear to be separated from each other by the N. massete-
ricus, which emerges from the incisura mandibulae and passes be-
tween these two muscles.

The lamina tertia of the M. masseter profundus posterior
described as being present beneath this muscle layer in Macaca, etc.
by Yoshikawa et al. could not be found in any of my Macaca cy-
clopis. Further, Yoshikawa et al. report that the M. masseter pro-
fundus is separated into the anterior and posterior parts by N.
massetericus in such primates as Japanese monkey and crab-eating
monkey, but such separation into special parts was not possible in
any of my cases. Therefore, it is not clear which area they had
referred to as the anterior part.

Bluntschli has also separated the M. masseter into the super-
ficial and deep layers, with further division of the deep layer by
the N. massetericus into the pars anterior and pars posterior. His
pars anterior corresponds to my M. masseter profundissimus while
the pars posterior is the M. masseter profundus in my cases.
IV. M. masseter profundissimus (figure 1-g)

This muscle, in view of the condition of origin and insertion, corresponds to the pars anterior of the M. zygomaticomandibularis of Toldt, the M. maxillomandibularis of Yoshikawa et al. or the pars anterior of the M. masseter profundus of Bluntschi. However, the condition of nerve supply, etc. of this muscle in Macaca cyclopis indicate that it simply is a part of the M. masseter and was called the M. masseter profundissimus since no need could be found for considering it a separate, independent muscle.

This muscle is located on the lateral side (superficial layer) of the M. temporalis and its lateral surface is adjacent with the anterior part of the M. masseter intermedius lamina prima and the inner surface of the M. masseter intermedius lamina secunda. That portion of the M. masseter superficialis lamina prima which is reflexed inward appears to wrap about the anterior edge of this muscle.

The origin occurs not only from almost the entire arcus zygomaticus, but extends further back beyond the arcus zygomaticus to near the area above the porus acusticus externus. The origin from the posterior half of the arcus zygomaticus arises from the upper edge and inner surface, while in the anterior half the origin is from the inner surface and lower edge. In either case, the origin is by muscle.

The part arising from the upper edge of the arcus zygomaticus, that is, the pars suprazygomatica (Toldt) first runs in antero-upward
direction and then arches over in antero-downward direction to insert muscularly into the tendon of the M. temporalis (the common tendon of insertion with the M. temporalis of Imai). The parts arising from areas other than the upper edge of the arcus zygomaticus run in antero-downward direction with lesser inclination the more anterior they are located, and the most anterior part runs almost vertically.

The insertion of this muscle is by muscle into the lateral surface of the processus coronoideus, the area near the middle of the incisura mandibulae and the fossa masseterica on the lateral surface of the ramus mandibulae, but the anterior part of the muscle also inserts into the powerful tendon of the pars anterior of the M. temporalis superficialis (Kikuya).

At the region of the incisura mandibulae, there is muscular fusion between this muscle and the M. temporalis. There is a pad of fatty tissue in front of this muscle which separates it from the pars anterior of the M. temporalis superficialis, but in the lower part of the field of insertion, there is union with the powerful tendon of insertion of the pars anterior of the M. temporalis superficialis.

Nerve supply (figure 3)

This muscle is supplied entirely by the N. massetericus. The N. massetericus, together with the N. temporalis profundus, N. pterygoideus externus and N. buccalis, emerges into the fossa

![Diagram of the M. Masseter of the Formosan Monkey]

- ai = m. alveolaris inf.
- at = m. auriculotemporalis
- b = m. buccalis
- ct = chorda tympani
- l = m. lingualis
- m = m. massetericus
- mh = m. mylohyoideus
- pe = m. pterygoideus ext.
- tpa = m. temporalis prof. ant.
- tpp = m. temp. prof. post.
infratemporalis from the foramen ovale on the lamina lateralis proc. pterygoideus and then runs upward between the M. pterygoideus externus and the Os temporale. A branch is first given off to the part of the M. masseter profundissimus which arises from the upper edge of the arcus zygomaticus and from the area above the porus acusticus externus. Then, near the incisura mandibulae, this nerve separates into three branches, one of which gives off a ramus to the part of the M. masseter profundissimus which arises from the inner side of the arcus zygomaticus. In many cases, this ramus after sending off further twigs into the muscular substance of the M. masseter profundissimus, extends further and enters into the pars anterior of the M. temporalis superficialis.

The second branch runs between the M. masseter intermedius and profundissimus, and at about the anterior edge of the M. masseter profundissimus, a ramus is given off which enters into the M. masseter profundissimus from the lateral side. This ramus further separates into two terminal branches which run to the M. masseter superficialis lamina prima and secunda.

The third branch runs lateralward and forward between the M. masseter profundissimus and profundus. After first giving off a ramus to the M. masseter profundus lamina prima and secunda, it separates into branches to the M. masseter superficialis lamina prima and secunda and to the M. masseter intermedius lamina prima and secunda.

Discussion

There is disagreement on the composition of the M. masseter and from where it is derived, but as mentioned by Yoshikawa et al. and Heinze et al., the findings are presumably influenced by the method used to separate the muscle or what guide has been used in the study of the composition.

Therefore, my study of the M. masseter in Macaca cyclopis was done according to the method used by Yoshikawa et al. in their detailed study of primates. That is, the guide used for the study of the composition of this muscle was the fact that this muscle shows layer formation and that the tendon and muscle of adjacent muscle layers are in opposite direction (the reversal relation of the tendon and muscular substance as described by Yoshikawa et al.). Emphasis was also placed on the course of the N. massetericus during the process of separating the muscle.

This method is felt to be more useful than the window technique of Bluntschli for the study of the composition of the layers of the
M. masseter and permits detailed examination of the nerve supply.

Furthermore, the part which I called the M. masseter profundissimus has been the subject of disagreement on where it should be classified and the use of this method made possible the clear identification of this part which corresponds to the M. zygomatico-mandibularis of Toldt and the M. maxillomandibularis of Yoshikawa et al.

Another reason for using this method is the necessity to use the same method in separating the muscle in order to be able to review the results of Yoshikawa et al.

1) The major studies on the M. masseter of primates include that of C. Toldt (1905), H. Bluntschli (1929), D. Stark (1933), H. Raven (1950) and Yoshikawa et al. (1962-69), while studies on the M. temporalis have been made by Imai et al. (1963). The study by Toldt involved prosimian (Lemur varius), platyrrhine (Ateles paniscus, Ateles arachinoides, Cebus fatuellus, Hapale penicillata), catarrhine monkey and anthropoid apes (Cynocephalus, Macaca rhesus, Semnopithecus, Orang-utan, Chimpanzee), the study by Bluntschli was done on Orang-utan, while Stark studied platyrrhine (Hapale penicullata, Leontocebus rosalia, Aotus Azare, Pithecia hissuta, Alonatta auratus, Cebus, Saimiris sciureus, Ateles, Lagothrix), and the study of Raven was on Gorilla. Yoshikawa et al. investigated prosimian (Galago, Tamarimus nigricollis), platyrrhine (Saimiri sciurea), catarrhine (Macaca irus, Macaca fuscata and Cercopithecus aethiops), anthropoid apes (Orang-utan, Gorilla, and Chimpanzee). On the other hand, Imai studied the M. temporalis of Japanese monkey and crab-eating monkey.

i) In the study of prosimian by Toldt, the M. masseter was subdivided as follows: The superficial layer which arises from the anterior half of the arcus zygomaticus; and the deep layer which is located on the inner side of the superficial layer and arises from the entire length of the lower edge of the arcus zygomaticus. However, the muscle bundle located between the M. masseter and the M. temporalis, and which arises from the inner surface of the arcus zygomaticus and inserts into the lateral surface of the processus coronoideus was considered separately from the M. masseter. He called this the M. zygomatico-mandibularis and regarded it as part of the M. temporalis.

On the other hand, Yoshikawa et al. have divided the M. masseter into the superficial, intermediate and deep layers, but the superficial and intermediate layers of his classification seem to cor-
respond to the so-called superficial layer in view of the location of their origin. His classification further separated the M. zygomaticomandibularis and the M. maxillomandibularis as part of the M. masseter. The origin and insertion of both these muscle bundles are the same, with origin from the inner surface of the arcus zygomaticus and from the area above the porus acusticus externus, and insertion into the ramus mandibulae. The M. zygomaticomandibularis is located in the deeper portion with the maxillomandibularis on top of it.

Consequently, the condition of origin and insertion suggests that the M. zygomaticomandibularis of Toldt corresponds to the combination of the M. zygomaticomandibularis and maxillomandibularis of Yoshikawa et al.

ii) In platyrrhine monkey, the M. masseter has been divided by Toldt into the superficial and deep layers. This superficial layer arises from the anterior half of the arcus zygomaticus (Cebus, Hapale) or from the root of the anterior part of the arcus zygomaticus (Ateles), and inserts into the lower edge of the ramus mandibulae. The deep layer of the M. masseter arises mainly from the lower edge of the posterior part of the arcus zygomaticus (Hapale) or contrarily from the lower edge of the anterior half of the arcus zygomaticus (Ateles), and inserts into the lateral surface of the ramus mandibulae. The M. zygomaticomandibularis, which was considered by him to be part of the M. temporalis, is said to be also present in Ateles as in Cynocephalus.

Stark has also separated the M. masseter into the superficial layer, which arises from the anterior half of the arcus zygomaticus, and the deep layer, which is located on the inner side of the superficial layer and arises from the entire arcus zygomaticus. His findings in Hapale and Cebus agree with those of Toldt, and the findings in Saimiris are also the same as in Hapale. The only difference in the findings of Stark from that of Toldt is the larger area of origin with one portion of the origin extending to as far as the maxilla in Ateles.

In contrast to this, in the study of Saimiri (squirrel monkey) by Yoshikawa et al., a separation was made into the M. masseter superficialis lamina prima and intermedia, which arises from the anterior half of the arcus zygomaticus, and the M. masseter superficialis lamina secunda, which arises from the entire length of the arcus zygomaticus, as well as the M. masseter profundus, which arises from the posterior half of the arcus zygomaticus.

In Hapale and Pithecia, Stark separated the portion located on
the inner side of the deep layer which arises from the inner surface of the arcus zygomaticus and inserts into the fossa masseterica of the ramus mandibulae as being the M. zygomaticomandibularis. The deep portion of the M. masseter in Aotus, however, was considered to correspond to this M. zygomaticomandibularis in view of its condition of origin and insertion. Furthermore, in Saimires, the part which was noted to arise from the fascia of the M. temporalis and unite with the deep portion of the M. masseter was regarded as one part of the M. zygomaticomandibularis. Thus, in the findings of Stark, the M. zygomaticomandibularis was considered to be a separate, independent part of the M. masseter. A further segment located on the inner side of the M. zygomaticomandibularis and on the lateral side of the M. temporalis which arose from the fascia of the M. temporalis was called the pars suprazygomatica of the M. temporalis. However, because the M. masseter and M. temporalis originally are formed from the same embryonic element, the M. zygomaticomandibularis and this pars suprazygomatica of the M. temporalis can not be clearly distinguished. Consequently, although Stark separated the M. zygomaticomandibularis as one part of the M. masseter, because of mixture with elements from the M. temporalis, he seems to have felt that it is difficult to decide which muscle it should be classified under.

In Saimiri, the part which arises from the inner surface of the arcus zygomaticus and from the fascia of the M. temporalis, and inserts into the lateral surface of the ramus mandibulae was classified by Yoshikawa et al. as the M. zygomaticomandibularis, but in addition to this the part located beneath the anterior part of the M. masseter profundus which arises from the arcus zygomaticus and inserts into the lateral surface of the ramus mandibulae was separated as the M. maxillo-mandibularis. Further, Yoshikawa et al. regarded both of these to be part of the M. masseter. The M. zygomaticomandibularis in Saimiri of Yoshikawa et al. corresponds to the combination of the major portion of the pars suprazygomatica of the M. temporalis and the M. zygomaticomandibularis of Stark.

iii) For catarrhine monkey, the M. masseter in Cynocephalus which arises from the anterior half of the arcus zygomaticus and inserts into the ramus mandibulae was divided into four layers by Toldt. In addition to this, the muscle which arises from the posterior half (posterior part) or anterior half (anterior part) of the arcus zygomaticus and inserts into either the processus coronoides (posterior part) or the tendon of the M. temporalis and linea obliqua of the ramus mandibulae (anterior part) was called the M. zygomatico-
mandibularis. This M. zygomaticomandibularis, however, was regarded by Toldt as being part of the M. temporalis. Howell and Straus have separated the M. masseter of Macaca rhesus into the superficial part and the deeper division. The superficial part is that section which arises from the anterior half of the arcus zygomaticus and inserts into the lateral surface of the ramus mandibulae, while the deeper division is that part which arises from the posterior half of the arcus zygomaticus.

For Macaca and Cercopithecus, Yoshikawa et al. have made a separation into the superficial, intermediate and deep masseter muscles which arise from the anterior half of the arcus zygomaticus. A further separation is made into the M. maxillomandibularis and the M. zygomaticomandibularis which were regarded as the improper masseter group. In other words, the muscle which arose from the medial surface and lower edge of the arcus zygomaticus with one part of its posterior section arising from the upper edge of the arcus zygomaticus, and inserted into the ramus mandibulae parallel with the tendon of the M. zygomaticomandibularis had been called the M. maxillomandibularis. On the other hand, the muscle beneath the M. temporalis superficialis which arose from the posterior surface of the lateral side of the torus supraorbitalis and which inserted into two parts, one the lateral surface of the ramus mandibulae (M. zygomaticomandibularis lamina prima) and the other the retromolar space (M. zygomaticomandibularis lamina secunda), had been termed the M. zygomaticomandibularis. These parts, however, have been regarded by many investigators to be part of the M. temporalis.

On the other hand, Imai who has similarly studied the condition in Macaca regarded the muscle called the M. zygomaticomandibularis by Yoshikawa et al. to be the M. temporalis in view of the innervation by the N. temporalis profundus. Further, the M. maxillomandibularis described by Toldt in Rodentia was considered by him to be a part which had separated or in the process of separating from the medial part of the M. masseter, and not to be found in man or monkey. Also, he felt that although the M. maxillomandibularis as described by Yoshikawa et al. may appear to be similar to this, it is entirely different and simply a part of the M. temporalis superficialis.

iv) For anthropoid apes, there is the description by Bluntschli, Raven, Yoshikawa, etc.

Bluntschli separated the M. masseter of Orang-utan into the superficial and deep layers. The superficial layer is the part arising from the anterior half of the arcus zygomaticus, while the deep layer is composed of the pars anterior which arises from the inner surface.
of the arcus zygomaticus and the pars posterior which arises from the posterior half of the arcus zygomaticus. Further, this pars posterior of the deep masseter muscle was called the M. zygomatico-mandibularis, but since the separation of the pars anterior of the deep masseter muscle from the superficial layer of the M. masseter or from the M. temporalis was simply an artificial division, he felt that the deep layer of the M. masseter was embryologically the area joining the M. masseter and the M. temporalis. Therefore, Bluntschli seemed to be of the view that the deep layer of the M. masseter including the M. zygomaticomandibularis had characteristics intermediate between the M. masseter and M. temporalis.

Raven separated the M. masseter of Gorilla into only the inner and outer parts. The origin of the inner part is from the anterior part of the arcus zygomaticus, while that of the outer part is from the posterior part and inner surface of the arcus zygomaticus as well as from the fascia of the M. temporalis.

Yoshikawa et al. made a classification into the superficial, intermediate and deep layers in Orang-utan, Gorilla and Chimpanzee. The parts with origin from the anterior half of the arcus zygomaticus are the superficial and intermediate layers, while that from the posterior half of the arcus zygomaticus is the deep layer. As in the case of Catarrhine, Yoshikawa et al. described the M. zygomatico-mandibularis and M. maxillomandibularis as being part of the M. masseter, but their M. zygomaticomandibularis arose from the lateral posterior surface of the torus supraorbitalis and inserted into the processus coronoideus and retromolar space, while the M. maxillomandibularis arose from the inner surface and dorsal edge of the arcus zygomaticus and inserted into the lateral surface of the processus coronoideus.

2) As mentioned above, from the findings in primates of different investigators the composition of the M. masseter is regarded as follows:

i) There is general agreement on the separation of the M. masseter into the superficial layer which arises from the area extending from the lateral side to the lower edge of the anterior half of the arcus zygomaticus, and the deep layer which arises from the posterior half of the arcus zygomaticus. My findings in Macaca cyclopis are not exceptional to this.

That is, my classification into the M. masseter superficialis and intermedius is in accord with that of Yoshikawa et al., but these two layers are grouped together as the superficial layer in the
classification of other investigators. My M. masseter profundus corresponds to the deep layer in the classification of other workers.

ii) The report of Yoshikawa et al. is highly unique, however, in that they alone have separated the M. masseter into the proper and improper masseter groups. The M. zygomaticomandibularis and M. maxillomandibularis which compose the latter group were regarded as independent muscles.

3) Next, an attempt was made to determine how other investigators have regarded these parts called the M. zygomaticomandibularis and M. maxillomandibularis in the classification of Yoshikawa et al. and also to determine the true nature of these parts.

In prosimian, both Toldt and Yoshikawa et al. have regarded the muscle bundle with origin from the inner surface of the arcus zygomaticus and insertion into the lateral surface of the ramus mandibulae to be the M. zygomaticomandibularis, but this was included as part of the M. temporalis whereas Yoshikawa et al. considered it to be part of the M. masseter. Neither report, however, gives a description of the nerve supply.

Descriptions for platyrrhine are available by Toldt (Ateles), Stark (Hapale, Cebus, Saimiris) and Yoshikawa et al. (Saimiri). Review of the findings on the origin and insertion showed that the results of Toldt and Stark are in almost complete agreement for the M. zygomaticomandibularis. In contrast to this, the M. zygomaticomandibularis of Yoshikawa et al. is composed by a wider range of elements than the M. zygomaticomandibularis of Toldt or Stark, and include the pars suprazygomatica of the M. temporalis, but there is no essential difference in the findings.

This part was regarded by Toldt to be part of the M. temporalis, while Stark felt that it was difficult to determine whether it is a part of the M. temporalis or the M. masseter. In contrast to this, Yoshikawa et al. were also in considering this as well as the M. maxillomandibularis to be part of the M. masseter.

Further, in catarrhine, the M. zygomaticomandibularis of Toldt and that of Yoshikawa et al. were found to be entirely different muscle bundles in view of their origin and insertion. However, the pars posterior of the M. zygomaticomandibularis of Toldt corresponded to the M. masseter profundissimus of Yoshikawa et al. and myself, while the pars anterior corresponded to the M. maxillomandibularis of Yoshikawa et al. and to the M. masseter profundissimus of myself.

Although Toldt was of the opinion that the M. zygomaticomandibularis is embryologically a part of the M. temporalis, the M.
masseter profundissimus which corresponded to this part in my classification was found to be always supplied by only the N. massetericus. Therefore, the so-called M. zygomaticomandibularis of Toldt and the M. maxillomandibularis of Yoshikawa et al. are felt to be simply parts of the M. masseter. Furthermore, the M. zygomaticomandibularis of Yoshikawa et al. is entirely different from that of Toldt, and even in my classification it has to be considered part of the M. temporalis in view of its origin, insertion and nerve supply.

Furthermore, in the study of Macaca by Imai et al., the part corresponding to the M. zygomaticomandibularis of Yoshikawa et al. was regarded to be the M. temporalis rather than the so-called M. zygomaticomandibularis in view of its nerve supply. Moreover, it was his view that the M. zygomaticomandibularis described by Yoshikawa et al. also is simply a part of the M. temporalis.

The M. zygomaticomandibularis of anthropoid apes described by Yoshikawa et al. (immature Orang-utan, Gorilla, Chimpanzee) and by Bluntschli (mature Orang-utan) is, as in the case of Catarrhine, an entirely different muscle in view of the state of origin and insertion.

In summary, Yoshikawa et al. classified their M. zygomaticomandibularis and M. maxillomandibularis in primates as belonging to the M. masseter, but the part classified by Toldt, Stark, etc. as the M. zygomaticomandibularis was of different nature even though the nomenclature is the same. The M. zygomaticomandibularis of Toldt corresponds rather to the part termed the M. maxillomandibularis by Yoshikawa et al. and to the part I called the M. masseter profundissimus. Further, it was found that the part called the M. zygomaticomandibularis by Yoshikawa et al. should be considered part of the M. temporalis rather than the M. masseter.

Moreover, the M. masseter profundissimus in my classification, that is, the so-called M. zygomaticomandibularis of Toldt (which corresponds to the M. maxillomandibularis of Yoshikawa et al.) is adhered firmly with the M. temporalis and is separated with difficulty, so that there is no definite accepted theory on whether it is part of the M. masseter or the M. temporalis. That is, Toldt has on the basis of its nerve supply and from the embryologic standpoint considered it part of the M. temporalis, whereas Imai et al., Yabumoto et al. and Yoshikawa et al. have regarded it as part of the M. masseter, while Bluntschli, Stark, etc. feel that elements of both are included. However, as I mentioned in the section on my results, there was no apparent need to consider it an independent muscle, and since the nerve supply is always by the N. massetericus it was felt to be part of the M. masseter, and thus I considered it more appropriate to regard it as the M. masseter profundissimus.
Summary

A study of the M. masseter was made bilaterally according to the technique of Yoshikawa et al. on a sample of 25 Macaca cyclopis.

1) A classification into the M. masseter superficialis (lamina prima and secunda), intermedius (lamina prima and secunda), profundus (lamina prima and secunda) and profundissimus was possible on the basis of the site and condition of origin and insertion, course of muscle bundles, etc. These parts were all supplied by branches from the N. massetericus.

2) The M. masseter superficialis lamina prima in many cases was found to show a formation corresponding to the pars reflexa of Rodentia.

3) In rare cases, conditions presumed to be variations of the M. masseter profundus were found.

4) The muscle located between the M. masseter and M. temporalis, with origin from the inner surface of the arcus zygomaticus and insertion into the lateral surface of the ramus mandibularis, which I called the M. masseter profundissimus is the part corresponding to the so-called M. zygomaticomandibularis of Toldt or the M. maxillomandibularis in the classification of Yoshikawa et al. The portion regarded as the M. zygomaticomandibularis by Yoshikawa et al. is an entirely different muscle from the M. zygomaticomandibularis of Toldt even though the nomenclature is the same and is a part of the M. temporalis.

The nerve supply also indicated that these parts belong to the M. masseter, and there was no apparent need to separate these parts and give them independent names as being part of the improper masseter group.

Reference

The M. Masseter of the Formosan Monkey


