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The M. pterygoideus externus and M. pterygoideus internus in Formosan Monkey.

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The authors have investigated on the Mm.pterygoideus externus and internus in a comparatively large sample of Formosan monkey (*Macaca cyclopis*). The origin, insertion, nerve supply and the relation with the surrounding muscles were studied. In addition, the results were compared with those of other primates and man.

As abnormal case in this study, the muscle which was similar to the M. pterygoideus proprius was found. As far as we have known, it was reported in very rare cases of human being, but it was never reported in other primates.

INTRODUCTION

The M. pterygoideus externus and M. pterygoideus internus together with the M. masseter and M. temporalis form the Mm. masticatorii in monkey similarly as in man.

The M. pterygoideus externus, which is separated from the M. temporalis by a layer of fat, appears to be independent of the M. pterygoideus internus being entirely different in direction of fasciculi and with no continuation or fusion of their fasciculi.

The few studies available concerning these muscles in primates include the report of H. Bluntschli (1929), D. Stark (1933) and E. Zuckerkandl (1900).

Recently, the authors had an opportunity to investigate these muscles, in a comparatively large number of Formosan monkey (*Macaca cyclopis*) and the present paper will describe the M. pterygoideus externus and M. pterygoideus internus. A discussion will also be made of the comparison with the findings in man.

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MATERIAL AND METHOD

The material consisted of 25 cases (9 males, 16 females) of *Macaca cyclopis* as in the previous study of the M. masseter and M. temporalis by Sanefuji and Kikuya. These animals, selected from the Satoh collection at the First Department of Anatomy of the Nagasaki University School of Medicine, had 10% formalin solution injected into the blood vessels and stored in this solution of the same concentration.

Inspection was done using magnifying lenses with illumination attachment, and dissection tweezers. The use of scalpel or scissors was limited to the minimum. Part of the mandibula and the lamina lateralis processus pterygoidei were resected as necessary.

FINDINGS AND DISCUSSION

First, an incision was made downward from the incisura mandibulae to the level of the arcus alveolaris, from where further incision in forward direction was made. When this flap together with the part of the M. temporalis which inserts into the inner surface of the ramus mandibulae is peeled off, the A. maxillaris (internus), N. buccalis, N. temporalis profundus anterior, N. massetericus, N. temporalis profundus posterior, N. alveolaris inferior and N. lingualis are exposed as well as a layer of fat. Removal of this fat layer reveals the lateral surface of the M. pterygoideus externus and M. pterygoideus internus.

Furthermore, when the glandulae submandibularis are removed from below, the M. pterygoideus internus in the area near the basis mandibulae as well as the relation between the M. pterygoideus internus and the M. masseter in the region near the angulus mandibulae can be examined.

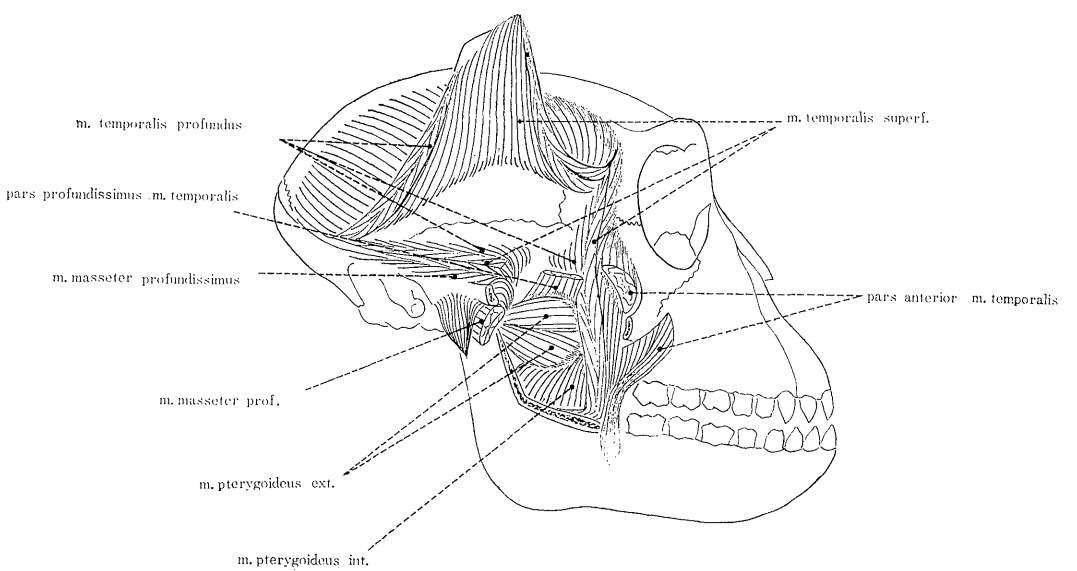


Fig. 1.

1. M. pterygoideus externus

The M. pterygoideus externus is a fan-shaped muscle which arises tendinously by two fasciculi of almost equal size from the lamina lateralis processus pterygoidei os sphenoidale. The upper edge of the superior head is separated from the M. temporalis by the crista infratemporalis, and the lower edge of the inferior head is at the lower margin of the lamina lateralis processus pterygoidei. The anterior part of this inferior head is partially under cover of the M. pterygoideus internus. A small area on the upper edge of the superior head is tendinous and is firmly adhered to the tendinous origin of the M. temporalis from the crista infratemporalis. The fasciculi of the superior head run downward and backward, while the inferior head which has a small tendinous area on lower edge similar to that on the upper edge of the superior head, runs upward and backward. Furthermore, the superior and inferior heads are adhered to each other tendinously at their insertion into the capsula articularis, discus articularis and fovea pterygoidea on the inner side of the processus condylaris mandibulae.

(1) Origin

a. Number of heads (figures 1 and 2)

The origin in some cases of *Macaca cyclopis* appeared to be by a single head, but this simply was a superficial observation, the origin usually being by two heads (43/50, 86%). The other cases appeared to arise by three heads, but there was no case of true origin by three heads from entirely different sites.

Furthermore, because the N. temporalis profundus anterior penetrated the superior head or the N. buccalis pierced the inferior head in some cases, the area bounded by these nerves appeared to be the third head.

The M. pterygoideus externus of mammals including primates usually has two heads (D. Stark, Howell & Straus, H. Bluntschli, and C. Toldt), but this muscle in *Ateles* and *Lagothrix* among platyrrhine monkey is reported to have a single head (Stark).

The differentiation of two or three heads has in many cases been based upon the external morphological finding of clefts between the fasciculi so that there is the possibility of errors in such classifications.

To study the condition of this muscle, instead of examining the M. pterygoideus externus from the outer side was done by many other investigators, we used the method of H. Freisfeld (1929) who found that "chiseling away the basis cranii to examine the M. pterygoideus externus from above permits differentiation of the heads by the direction of the fasciculi."

In man, there usually also are two heads (P. Eisler, 1912; Iwata, 1959; Nakayama, 1932; W. Ehrich, 1926; and H. Wagenseil, 1936, 1964). Cases with three heads are comparatively few (about 10%), and cases with one head (Sommerling-Theile, and Iwata) are more infrequent (3.8%, Iwata).

Among cases with three heads in man, the middle head has frequently been reported by many investigators to arise from the lamina lateralis processus pterygoidei, but

there also are cases with origin from the spina angularis (Ehrich) and cases with origin from the tendinous arch spanning the fissura pterygomaxillaris (Wagenseil) or from the tendinous arch extending from the crista infratemporalis to the lamina lateralis (Wagenseil).

These descriptions indicate that these cases truly have three heads which arise from entirely separate sites, and seem to be completely different in nature from the middle head found in *Macaca cyclopis* which, as mentioned above, had been formed by the splitting of the lower region of the superior head into two parts by the N. temporalis profundus anterior and N. buccalis.

The case with a single head in the report of Iwata had been due to the firm adhesion between the superior and inferior heads which made identification of two heads impossible, rather than being due to the absence of the superior head such as reported by Sommerling-Theile.

b. Site of origin of the muscular heads

Examination of the site of origin of the muscular heads revealed that the superior head in all cases was from the area extending from the planum infratemporale to the lamina lateralis processus pterygoidei, while the inferior head arose from an area about mid-way down the height of the lamina lateralis processus pterygoidei.

The origin in primates has been described as the planum infratemporale and lamina lateralis processus pterygoidei (platyrrhine monkey, Stark; orang-utan, Bluntschli), with the superior head being from the infratemporal crest and fossa of the outer surface of the

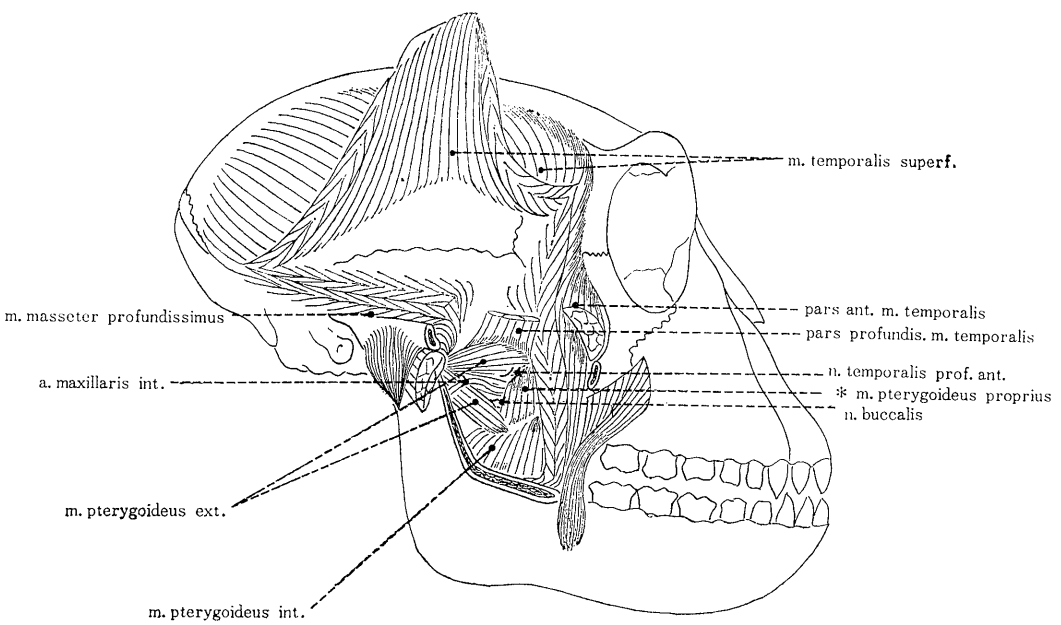


Fig. 2

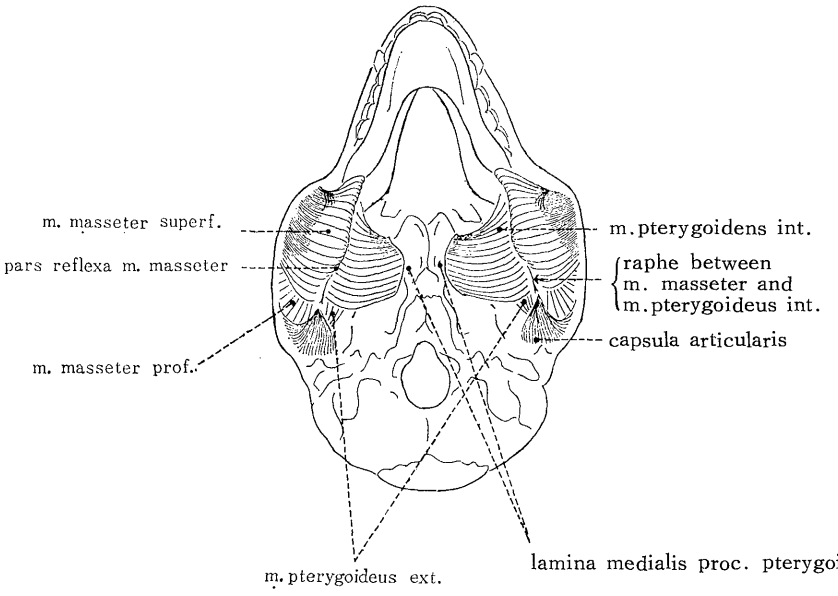


Fig. 3.

sphenoid bone, and the inferior head from the lamina lateralis of the processus pterygoideus (Howell & Straus). The descriptions by Toldt and Raven are also similar to this.

In man, the origin of the superior head involves a considerably extensive area and variations seem to be frequent (Nakayama, Suzuki, Iwata, Wagenseil, and Ehrich).

In *Macaca cyclopis*, however, the origin was found to be from only the facies infratemporalis and lamina lateralis.

Particularly, cases with origin from the tendinous arch or from an area further upward beyond the crista infratemporalis such as reported in man could not be found in a single case of *Macaca cyclopis*.

On the other hand, the inferior head is reported to arise from the lamina lateralis processus pterygoidei and the adjacent tuber maxillae (Nakayama, Suzuki, Iwata, Wagenseil, and Ehrich) which hardly differs from that in *Macaca cyclopis*.

c. Relationship to nerves (figure 2)

The N. temporalis profundus anterior, N. temporalis profundus posterior or N. buccalis pass between the two heads or through the belly of this muscle. The following patterns were noted in these relationships:

(i) The N. temporalis profundus anterior and N. buccalis pass between the two heads (44%).

(ii) The N. temporalis profundus anterior, N. temporalis profundus posterior or N. buccalis penetrates one of the heads (56%).

These patterns may be further subdivided as follows: Cases of penetration of the superior head by the N. temporalis profundus posterior (18%); cases of penetration of the superior head by the N. temporalis profundus anterior (16%); cases of penetration

of the inferior head by the N. buccalis (10%); cases of penetration of the superior head by the N. temporalis profundus posterior and penetration of the inferior head by the N. buccalis (8%); and cases of penetration of the superior head by both the N. temporalis profundus anterior and N. temporalis profundus posterior with the N. buccalis passing between the two heads (4%).

No case in *Macaca cyclopis* was found to have the N. trigeminus passing between the muscle such as occasionally reported in man (Kreutzer).

(2) **Insertion** (figures 4 and 5)

In *Macaca cyclopis*, both the superior and inferior heads always inserted by a common tendon into the discus articularis, capsula articularis and fovea pterygoidea.

In other primates, the insertion has likewise been reported to be the processus condylaris, discus articularis, capsule of the jaw (platyrrhine monkey; Stark), mandibular

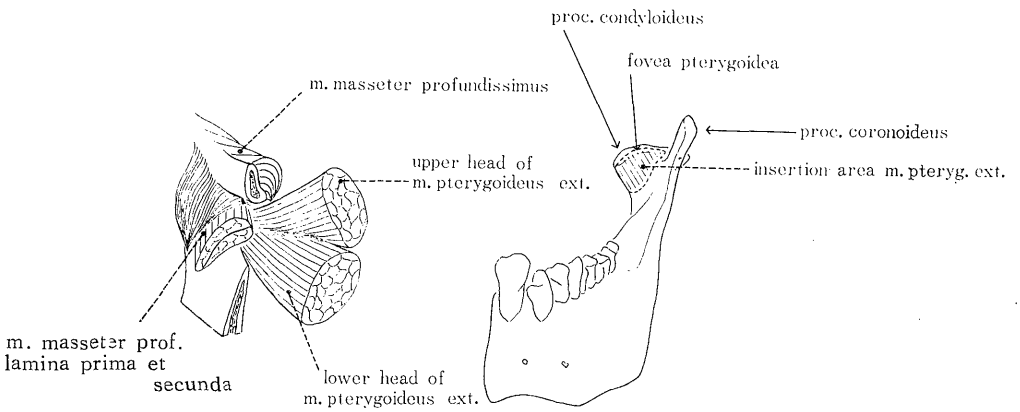
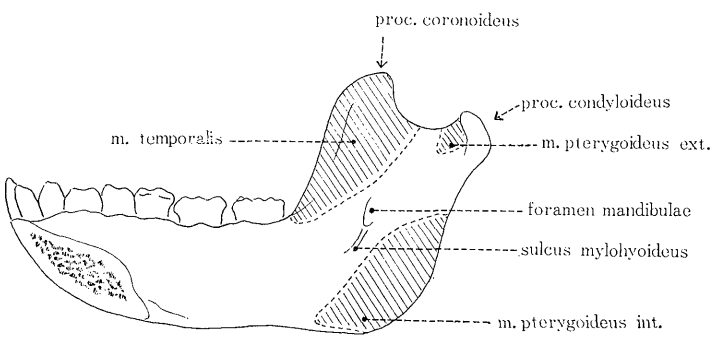


Fig. 4.



insertions area of the muscles
(inner surface, ramus mandibulale)

Fig. 5.

condylus (macaque; Howell & Straus), capsule of the jaw, neck of the condyle (gorilla; Raven), capsule of the jaw (orang-utan; Bluntschli), etc. Thus, the insertion in primates, like the origin, has little variation.

On the other hand, in man, the insertion of the superior and inferior heads has been reported to be as follows: (**a**) Most frequently the insertion is by a common tendon, with the two heads fused; (**b**) occasionally there is crossing over of the superior and inferior heads; and (**c**) in some cases the two heads insert completely independently (Nakayama and Iwata).

Therefore, the condition of insertion in *Macaca cyclopis* is uniform with little variation.

(3) **Nerve supply** (figure 6)

The N. pterygoideus externus in *Macaca cyclopis* emerges from the upper foramen ovale together with the N. massetericus, N. temporalis profundus posterior, N. temporalis profundus anterior and N. buccalis, and immediately enters into the M. pterygoideus externus.

However, the formation of a plexus by small rami of the N. pterygoideus externus such as described by Eisler could not be found between the two heads.

In rhesus monkey, K. Christensen has reported that the anterior part of the N. mandibularis, during its course forward between the two heads of the M. pterygoideus externus, gives off the N. pterygoideus externus, after which the main branch continues forward to become the N. buccinatorius which terminates in the wall of the cheek and mouth. The N. buccinatorius (or buccalis) and the N. pterygoideus externus likewise formed a common trunk in *Macaca cyclopis*.

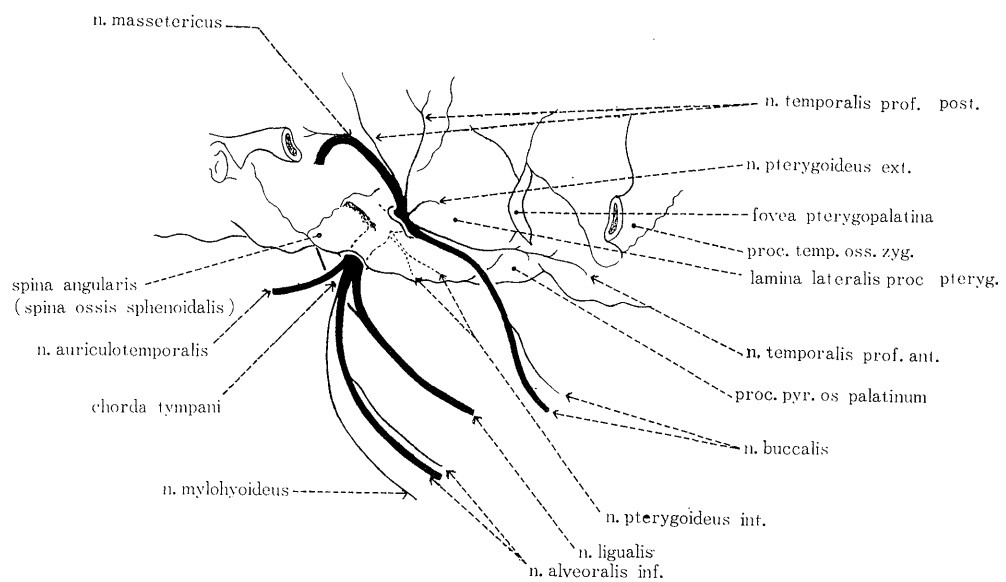


Fig. 6

(4) **Variations** (figure 2)

According to Eisler, in addition to abnormalities of the M. pterygoideus externus such as a single head, tendinous changes, etc., there may be the presence of muscle in man called the M. pterygoideus proprius (Henle). A muscle corresponding to this was found in *Macaca cyclopis* (case number 104, male, right side).

That is, a muscle was found which arose by tendon from an area extending from the crista infratemporalis to the lamina lateralis processus pterygoidei. One part of its upper edge was covered by the origin of the M. pterygoideus externus. As this muscle descended almost vertically beyond the apparent middle head, the posterior edge was covered by the origin of the inferior head of the M. pterygoideus externus. The insertion was into the lamina lateralis processus pterygoidei. The upper four fifths of this muscle was tendinous, while the lower one fifth was muscular. It measured 4 mm in greatest width and 10 mm in greatest length. The A. maxillaris internus was found passing between this muscle and the M. pterygoideus externus. The nerve supply could not be determined. There apparently is no report of such a muscle in other primates.

2. M. pterygoideus internus

(1) **Origin and insertion** (figures 1 and 5)

The M. pterygoideus internus in *Macaca cyclopis* is formed by the part that arises from the lower edge and outer surface of the processus pyramidalis os palatinum and lamina lateralis processus pterygoidei, and the part arising from the fossa pterygoidea, i. e. the area bounded by the back side or inner surface of the lamina lateralis and lamina medialis of the processus pterygoideus. This latter part is penetrated from behind by the N. pterygoideus internus. Both parts arise musculo-tendinously, furthermore, the part arising from the processus pyramidalis os palatinum and lamina lateralis processus pterygoidei is located on top of the inferior head of the M. pterygoideus externus.

The fasciculi of the anterior region descend in slightly forward direction, but the fasciculi further dorsal run downward and backward with increasing inclination to the insertion into the tuberositas pterygoidea of the mandibula.

Moreover, the field of insertion never extended beyond the field of insertion of the M. masseter into the lower and posterior edge of the mandibula. Furthermore, the upper edge of the field of insertion never went beyond the sulcus mylohyoideus.

(2) **Structure of the muscle**

The M. pterygoideus internus consists of : (*i*) the antero-lateral part which arises primarily from the antero-lateral surface of the lamina lateralis processus pterygoidei; and (*ii*) the medial part which arises from within the fossa pterygoidea. These parts, however, are not clearly demarkated by tendon such as in the case of the M. masseter. This muscle presents a very complicated condition and appears to be a feather-like muscle centering around the tendons of origin and insertion, respectively.

The condition of this muscle hardly differed from the description in man by Eisler and Iwata. The similarity of the internal structure of the M. pterygoideus internus and the M. masseter described in cattle by W. Heinze (1964) could not be found in *Macaca cyclopis*.

The above findings are largely similar to the description in primates by Toldt, Bluntschli, Stark, etc. The report of Howell & Straus on rhesus monkey differs, however, in that no mention is made of origin from the lateral surface of the lamina lateralis processus pterygoidei.

The condition did not differ greatly from the description in man, except that no case had origin from the tuber maxillare or from the ligamentum pterygospinosum such as mentioned by Wagenseil.

(3) **Relationship to surrounding muscles** (figure 3)

At the insertion into the basis mandibulae, the pars reflexa of the M. masseter was frequently found overlapping the M. pterygoideus internus (74%). In man, fusion or interdigitation is frequently reported between these two muscles (Nakayama, Iwata, and Ehrich). None of my cases, however, was found to have fusion, continuation, etc. with the M. pterygoideus externus, M. temporalis or M. masseter such as described in man.

(4) **Nerve supply** (figure 6)

The nerve to this muscle is given off behind the fossa pterygoidea from the N. mandibularis which separates from the inner side of the part where the common trunk of the N. massetericus, N. temporalis profundus, N. buccalis and N. pterygoideus externus divides from the common trunk of the N. lingualis, N. alveolaris inferior, N. mylohyoideus and N. auriculotemporalis. It soon separates into two branches which enter the muscle belly from the upper posterior edge of the M. pterygoideus internus.

This condition is similar to the description made of the N. pterygoideus internus in rhesus monkey by K. Christensen (1933).

SUMMARY

The M. pterygoideus externus and M. pterygoideus internus which form part of the Mm. masticatorii were examined in 25 cases of Formosan monkey (*Macaca cyclopis*).

1. *M. pterygoideus externus*

(1) This muscle arises tendinously by two heads from the lamina lateralis processus pterygoidei of the os sphenoidale, and inserts into the capsula articularis and fovea pterygoidea. The superior and inferior heads are united and fused at the insertion.

(2) In many cases, the N. temporalis profundus anterior and N. buccalis pass between these two beads.

(3) The nerve supply is by the N. pterygoideus externus which emerges from the foramen ovale together with the N. buccalis, N. massetericus and N. temporalis pro-

fundus.

(4) The M. pterygoideus proprius (Henle) which is occasionally seen in man as a variation was found.

2. *M. pterygoideus internus*

(1) This muscle arises musculo-tendinously from the processus pyramidalis os palatinum, lamina lateralis processus pterygoidei and fossa pterygoidea. The insertion is musculotendinously into the tuberositas pterygoidea of the mandibula.

(2) This muscle may be differentiated into the anterolateral part which arises from the lateral surface and lower edge of the processus pyramidalis and lamina lateralis, and the medial part which arises from the fossa pterygoidea. This sub-division, however, was not as definite as in the M. masseter. The muscle has a complicated feather-like structure with an internal tendon.

(3) The nerve supply is by the N. pterygoideus internus which separates behind the fossa pterygoidea from the N. mandibularis.

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