An Anatomical Study of the Muscles That Attach to the Articular Disc of the Temporomandibular Joint

KOSUKE MATSUNAGA,1 AKIRA USUI,2 KUMIKO YAMAGUCHI,1 AND KEIICHI AKITA1*

1Unit of Clinical Anatomy, Graduate School, Tokyo Medical and Dental University, Tokyo, Japan
2Pediatric Dentistry, Nihon University School of Dentistry at Matsudo, Chiba, Japan

The masticatory muscles are generally described as the muscles that originate from the cranium and insert on the mandible. Some of the masticatory muscles also insert into the articular disc of the temporomandibular joint. Although there are numerous reports of studies on the attachment of the fibers to the disc, most reports discuss only one muscle. We have shown that the masticatory muscles are not simply a group of clearly independent muscles, but that these muscles contain various transitional muscle bundles among the major muscles. From this point of view, we carried out minute dissection of the collective muscles and muscle bundles surrounding the temporomandibular joint. We dissected 40 head halves of 20 Japanese cadavers (10 males, 10 females: average 79.6 yr). After complete removal of the bony elements, the structures surrounding the temporomandibular joint were investigated en-block. In all specimens, the superior surface of the upper head of lateral pterygoid and the midmedial muscle bundle were attached to the disc. In some specimens, the discotemporal bundle, zygomaticomandibularis, and masseter were attached to the anterior surface of the disc. The total vector of these muscles pulls the disc anteriorly. In contrast, the vector of the muscles to the condylar processes of the mandible pulls the mandible medially. From these observations, it seems that the fibers which attach to the disc act to steady the disc against the masticatory movement. Clin. Anat. 22:932–940, 2009. © 2009 Wiley-Liss, Inc.

Key words: articular disc; condylar process; temporomandibular joint; masticatory muscles; clinical anatomy

INTRODUCTION

The masticatory muscles have been classified in different ways according to the varied findings of human anatomical, comparative anatomical, and embryological studies. Numerous studies have classified the masticatory muscles into lateral and medial groups according to their positions relative to the mandible or the main trunk of the mandibular nerve (Sappey, 1876; Reuter, 1897; Gegenbaur, 1903; Lewis, 1910; Edgeworth, 1914; Lubosch, 1938; Romer, 1962; Paturet, 1964; Rayne and Crawford, 1971; Terada and Sato, 1982; Tomo, 1990; Tomo et al., 1993). Edgeworth (1914), in his classification based on comparative embryological findings in mammals, showed that the common anlage of the masticatory muscles is first divided into medial and lateral parts; the medial part becomes the medial...
**Fig. 1.** The area of the attachment of the lateral pterygoid muscle on the condylar process of the mandible. The area is indicated as purple. **A**, anterior aspect (right). **B**, anteromedial aspect (right). Cp, condylar process; Cr, coronoid process; Mcp, medial attachment of capsule; Mh, mandibular head; Pf, pterygoid fovea.

**Figure 2** (Legend on next page.)
pterygoid, and the lateral part becomes the other muscles.

In previous reports, we described the positional relationships between the muscles and branches of the mandibular nerve in detail, as well as the pattern of ramification (Shimokawa et al., 1998, 1999; Akita et al., 2000, 2003; Sakamoto and Akita, 2004a; Usui et al., 2008). In those studies, we reported many variations in the positional relationships between the muscular bundles and the branches of the mandibular nerve. In addition, we stated that the masticatory muscles are not a group of clearly independent muscles but rather there are various transitional muscle bundles within the group.

The masticatory muscles are generally described as muscles, which originate from the cranium and insert on to the mandible. Sometimes, however, muscle bundles are attached to the articular disc. In the previous reports, the various transitional muscle bundles have often been observed in the lateral part of the masticatory muscles. In this study, we investigated the muscles and the muscle bundles that are attached to the articular disc and the mandible around the temporomandibular joint. Because the masticatory muscles are not distinctly divided into clear independent muscles, the various muscle bundles attached to the disc and the mandible at the temporomandibular joint must show functional cooperation. Here, we report the variations of the attaching muscle bundles and discuss the possible functions of these muscles and muscle bundles to derive an anatomic basis for physiological and clinical studies of temporomandibular functions.

MATERIALS AND METHODS

Forty head halves of 20 Japanese cadavers (10 males, 10 females; average 79.6 yr) were used for this study, and these materials were obtained from the dissecting room of the School of Medicine, Tokyo Medical and Dental University. The cadavers were fixed in 10% formalin and preserved in 30% alcohol. To examine the lateral pterygoid, temporalis, and masseter muscles, and especially the muscle bundles, which are attached to the disc of the temporomandibular joint in situ, the bony elements (with particular care for the temporal bone and the sphenoid bone) were entirely removed from the inside of the cranium in accordance with the superior approach reported by Pinto (1962) and Akita et al. (2000). In addition, the zygomatic arch was carefully removed to preserve the muscle bundles attached to the arch. The mandible was also removed, except for the region proximal to the mandibular neck. After the en bloc removal of the masticatory muscles, the positional relationships of the muscles and the nerves were examined with special reference to the relationships between the muscle bundles and the masseteric nerve. The attachments of these muscles and their small muscle bundles to the articular disc and mandible were investigated under a binocular microscope.

In this study, we investigated the attachments of the muscle bundles to the mandible, the articular disc, and the articular capsule under a binocular dissecting microscope. The present results show the number of specimens in which the disc attachment was clearly observed.

RESULTS

Lateral Pterygoid Muscle

The lateral pterygoid muscle originated from the lateral surface of the lateral pterygoid plate, the infratemporal crest, and the inferior surface of the greater wing of the sphenoid bone. This muscle mainly inserted into the medial half of the anterior surface (pterygoid fovea) and the medial surface of the condylar process of the mandible (Fig. 1). We attempted to determine which specific part of the muscle was attached to the disc.

The lateral pterygoid muscle is generally described to be composed of two parts: the superior (upper) and inferior (lower) heads. Most of the muscle fibers of the superior head were inserted into the condylar process. In all specimens, however, it was difficult to identify the border between the two parts in the posterior region (Fig. 2A). Next, we classified them according to the site of origin, and the areas of the origins were divided into the following two groups: the horizontal group, the muscle fibers, which originated from the inferior surface of the greater wing of the sphenoid bone, and the longitudinal group, those from the lateral surface of the lateral pterygoid plate (Usui et al., 2008). The muscle fibers, which originated from the anterior half of the lateral pterygoid plate, inserted into the pterygoid fovea. On the

---

Fig. 2. Insertion regions of the lateral pterygoid muscle. A: Right. Superomedial aspects of the lateral pterygoid muscle and the temporals muscle. The upper head of the lateral pterygoid muscle was covered by the articular disc of the temporomandibular joint. B: Right. Superomedial aspects of the lateral pterygoid muscle and the temporals muscle after removal of the articular disc. Same specimen as (A) most of the fibers of the upper head of the lateral pterygoid muscle inserted into the pterygoid fovea of the condylar process of the mandible. C: Right. Medial aspect of the lateral pterygoid muscle and the temporals muscle. Fibers of the lower head of the lateral pterygoid muscle inserted into the medial surface of the condylar process. D: Right. Lateral aspect of the proximal region of the lateral pterygoid muscle. An example of the typical insertions of the upper head of the lateral pterygoid muscle is shown in this photograph. The superior thin region of the upper head inserted into the inferior surface of the articular disc, and most of the muscle fibers of the upper head inserted into the pterygoid fovea in the mandibular head. Cp, condylar process; Di, articular disc of the temporomandibular joint; LPI, lower head of the lateral pterygoid muscle; Lu, upper head of the lateral pterygoid muscle; Mh, mandibular head; MS, masseter; TM, main part of the temporals.
Fig. 3. Muscle bundles of the temporalis muscle that inserted into the articular disc of the temporomandibular joint. The midmedial muscle bundle of the temporalis muscle was situated between the upper head of the lateral pterygoid muscle and the main part of the temporalis. In addition, the discotemporal muscle bundle of the temporalis muscle was situated in the posteromedial region of the main part of the temporalis muscle. Both of the muscle bundles were attached to the inferior surfaces of the disc. Figure 3B shows that the main trunk of the masseteric nerve ran between the midmedial muscle bundle and the discotemporal muscle bundle. Di, articular disc of the temporomandibular joint; DT, discotemporal muscle bundle of the temporalis; Lpu, upper head of the lateral pterygoid muscle; MM, midmedial muscle bundle of the temporalis; Msn, masseteric nerve; TM, main part of the temporalis.

Figure 4 (Legend on next page.)
contrary, the muscle fibers, which originated from the posterior half of the plate, mainly inserted into the medial surface of the condylar process (Fig. 2B and 2C). There was no obvious border between the areas of the insertions of the muscle fibers of the horizontal and longitudinal groups. Only a thin part of the superficial layer of the muscle fibers, which originated from the inferior surface of the greater wing, was attached to the inferior surface of the articular disc in all specimens (Fig. 2D).

**Midmedial Muscle Bundle of the Temporals**

After removal of the squamous part of the temporal bone, a small muscle bundle was found (Fig. 3). This muscle bundle was located on the medial surface of the temporals and ran posteriorly and therefore was named the “midmedial muscle bundle of the temporals” (Akita et al., 2000). The midmedial muscle bundle originated from the part of infratemporal fossa just posterior to the area from which the longitudinal muscle bundle (sphenomandibularis (Dunn et al., 1996): the anteromedial muscle bundle of the temporals (Shimokawa et al., 1998)) originated. The bundle inserted into the anteroinferior surface of the articular disc of the temporomandibular joint just lateral to the area of insertion of muscle fibers of the superior head of the lateral pterygoid muscle in all specimens. In 14 specimens (eight right, six left), the midmedial bundle was tightly adjoined to the lateral surface of the upper head of the lateral pterygoid in the posterior half of the muscle and inserted on to the condylar process as well as into the articular disc.

**Discotemporal Muscle Bundle of the Temporals**

In 11 specimens (five right and six left), a small muscle bundle was found on the posterior surface of the temporals (Fig. 3). This bundle was distinguished from the midmedial muscle bundle of the temporals, because the masseteric nerve passed between the two muscle bundles. The bundle, named the discotemporal muscle bundle (Le Toux et al., 1989; Akita et al., 2000), originated from the medio-posterior surface of the temporals and ran infero-posteriorly. It inserted into the anteroinferior surface of the articular disc of the temporomandibular joint just lateral to the area of midmedial muscle bundle attachment.

**Zygomaticomandibularis**

A muscle bundle situated between the temporals and the masseter was observed in all specimens (Fig. 4A). The anterior border of this muscle joined the medial surface of the anterior region of the masseter, and the posterior border joined the posterior lateral surface of the posterior region of the temporals. This muscle bundle was named the zygomaticomandibularis (Toldt, 1905; Sicher and DuBrul, 1970). No nerve branch was found between the zygomaticomandibularis and the temporals (Shimokawa et al., 1999). The zygomaticomandibularis and the masseter were clearly identified, however, because the main trunk of the masseteric nerve ran between the two muscles. The zygomaticomandibularis originated from the most posterior region of the zygomatic arch and the medial surface of the aponeurosis of the temporals and inserted into the lateral surface of the coronoid process and the aponeurosis of the temporals. In 10 specimens (six right and four left), the superoposterior part of the muscle fibers extended to the articular disc of the temporomandibular joint and attached to the anteroinferior surface of the disc (Fig. 4B and 4C).

**Masseter**

Based on the directions of the muscle bundles of the masseter, the muscle seemed to be composed of two or more layers, and definite borders between layers were observed from the lateral aspect. In the specimen shown in Fig. 4A, the muscle seemed to be composed of three layers: anterolateral, middle, and posteromedial layers. The anterolateral layer originated from the anterior third of the lateral surface of the zygomatic arch, ran inferoposteriorly, and inserted into the angle of the mandible. The middle layer originated from the middle third of the inferior border of the zygomatic arch and inserted into the middle region of the lateral surface of the ramus of the mandible. The posteromedial layer originated from the posterior third of the inner surface of the arch, ran inferiorly, and inserted into the lateral surface of the coronoid process. Thus, the posterome-

---

**Fig. 4.** Masseter muscle and zygomaticomandibularis muscle. A: Right. Lateral aspect. The zygomaticomandibularis is located between the masseter and the main part of the temporals muscle. In this specimen, the masseter looks to be composed of three layers. The deep layer is indicated by an asterisk. In this specimen, the deep layer was not inserted into the articular disc or the articular capsule. B: Right. Posterior aspect. The posterior muscle fibers of the zygomaticomandibularis and the deep layer of the masseter muscle (indicated by an asterisk) were attached to the articular disc. C: Right. Medial aspect after removal of the lateral pterygoid muscle and the midmedial muscle bundle of the temporals. The mandibular head was also removed. The muscle bundles of the zygomaticomandibularis and the deep layer of the masseter muscle (indicated by an asterisk) were attached to the inferior surface of the anterior region of the articular disc. D: Right. Lateral aspect. In this specimen, the layered structure of the masseter muscle was not clearly visible. The posteromedial muscle bundle of the masseter muscle was attached to the lateral surface of the articular capsule of the temporomandibular joint. Ac, articular capsule; Cp, condylar process; Di, articular disc of the temporomandibular joint; MS, masseter; TM, main part of the temporals; ZM, zygomaticomandibularis muscle.
DISCUSSION and the Articular Disc

In all specimens, the lateral pterygoid muscle inserted into the medial surface of the condylar process of the mandible and the medial half of the pterygoid fovea. In addition, the midmedial muscle bundle of the temporalis was attached to the pterygoid fovea in 35% of specimens. In all specimens, the superior surface of the upper head of the lateral pterygoid and the midmedial muscle bundle attached to the disc. In many specimens, the discotemporal bundle (11/40; 27.5%), zygomaticomandibularis (10/40; 25%), and masseter (18/40; 45%) were attached to the anterior surface of the disc. The disc of the temporomandibular joint was thus attached to many components of the masticatory muscles. On the disc, the area of muscle attachments was large, and it was situated laterally. In contrast, the area of muscle attachments to the condylar process was situated medially.

Insertions to the Condylar Process and the Articular Disc

In all specimens, the lateral pterygoid muscle was situated close to the articular disc of the temporomandibular joint and the condylar process. In 18 specimens (eleven right and seven left), the posteroomedial layer of the muscle was attached to the lateralmost region of the anteroinferior surface of the disc (Fig. 4B and 4C). In four specimens (two right and two left), the medial surface of the layer attached to the lateral surface of the condylar process; in these examples, there were no muscle fibers attached to the inferior surface of the disc (Fig. 4D).

To understand the movement of the temporomandibular joint, it is important to determine the morphological relationships among the masticatory muscles, condylar process of the mandible, and the disc. In general, the masticatory muscles include the masseter, temporalis, and lateral pterygoid and medial pterygoid muscles. In addition to these muscles, many small muscle bundles have been observed in this region, and they are thought to modify the masticatory movements (Toldt, 1905; Sicher and Dubur, 1970; D. Toux, et al., 1989; Dunn et al., 1996; Shimokawa et al., 1998; Akita et al., 2000). Numerous reports discuss the nerve supply to these muscles (Sappon, 1876; Reuter, 1897; Gegenbaur, 1903; Lewis, 1910; Edgeworth, 1914; Lubosch, 1938; Romer, 1962; Paturet, 1964; Rayne and Crawford, 1971; Terada and Sato, 1982; Tomo, 1990; Tomo et al., 1993) and indicate the importance of the branching pattern of the mandibular nerve and positional relationships among the branches and the masticatory muscles. The masticatory muscles are divided into two groups: the medial group, which contains the medial and lateral pterygoid muscles, and the lateral group, which contains the masseter and the temporalis muscle (Sappon, 1877). There is another classification for these muscles based on comparative anatomical studies (Gegenbauer, 1903; Lubosch, 1918) and comparative embryological studies concerning the positional relationship of the mandibular nerve and the masticatory muscles. The masticatory muscles are thereby divided into a different two groups: the medial group, which contains the medial pterygoid muscle, and the lateral group, which contains the lateral pterygoid, masseter, and temporal muscle. Lubosch (1918) stated that the lateral pterygoid muscle is not an independent muscle but rather the deepest muscle bundle of the temporalsis muscle. From the viewpoint of nerve supply, it is obvious that there is no critical border within the masticatory muscles because the main trunk of the mandibular nerve often pierces the lateral as well as the medial pterygoid muscle (Sakamoto and Akita, 2004a,b; Usui et al., 2008).

Our group has reported the masticatory muscle group as one large muscle mass based on analysis of the precise nerve branching pattern of the mandibular nerve (Shimokawa et al., 1998, 1999; Akita et al., 2000, 2001, 2003; Sakamoto and Akita, 2004a,b; Usui et al., 2008). In these studies, each muscle of the masticatory muscle group is distributed to fill the space between the branching patterns of the mandibular nerve. As a result, the masticatory muscle turns out to be a complex muscle composed of many independent functional units.

Although there are many reports on the muscular bundles to the articular disc of the temporomandibular joint (Rees, 1954; Coully et al., 1975; Meyenberg et al., 1986; Myers, 1988; Le Toux et al., 1989; Gaudy et al., 1992; Merida Velasco et al., 1993; Schmolke, 1994; Loughner et al., 1996; Akita et al., 2000; Bravetti et al., 2004), the focus of each report is restricted to a single muscle without consideration of the total masticatory musculature mass. In addition, it had been generally described that most of the fibers of the upper head of the lateral pterygoid muscle attach to the articular disc, and the most of the fibers of the lower head attach to the pterygoid fovea (Rees, 1954; Troiano, 1967; Porter, 1970; Sugisaki et al., 1986; Wilkinson, 1988). However, in our macroscopic findings of the insertion of the lateral pterygoid muscle (Usui et al., 2008), we showed that only a thin superficial layer of the muscle fibers is attached to the articular disc. For this study, we removed the whole bony element around the temporomandibular joint, and the masticatory muscle was taken out as one mass to preserve the positional relationships among the bundles. The pattern of attachment to the disc and the positional relationships of each muscle bundle were determined within the mass. This original method (Shimokawa et al., 1998, 1999, Akita et al., 2000, 2003) is useful for the observation of whole small bundles in combination with the major masticatory muscles. It is widely known that the lateral pterygoid muscle attaches to the condylar process of the mandible and the disc of the temporomandibular joint. In addition to the lateral pterygoid, fibers from the temporalis, the zygomaticomandibularis muscle, and the masseter were observed to attach to the disc.

Some reports discuss the attachment of the fibers from the temporalis to the disc (Meyenberg et al., 1986), and the Articular Disc

...
because the main trunk of the masseteric nerve runs
between the two muscles. Edgeworth (1914) pro-
posed that the anlage of the masseter and the zygo-
maticomandibularis arises from the posterior part of
the common anlage of the masticatory muscles and
migrates anterolaterally. Shimokawa et al. (1999)
described the relationships among the masseter, the
zygomaticomandibularis, and the temporalis based
on the positional relationships between the muscles
and the masseteric nerve. The deep layer of the
masseter is thus considered to be derived from
the most posterior part of the common anlage of
the masticatory muscles. In addition, the zygomatico-
mandibularis is situated between the temporalis and
the masseter.

The condylar process of the mandible and the
articular disc were attached to muscle bundles,
which arose from the lateral pterygoid muscle, the
temporalis, the zygomaticomandibularis, and the
masseter. The condylar process of the mandible
was attached mainly to the lateral pterygoid muscle.
The lower head of the lateral pterygoid muscle inserted
into the medial surface of the condylar process of
the mandible and the upper region of the pterygoid
fossa, and the upper head of the pterygoid muscle
inserted into the upper region of the fossa. Thus, the
condylar process of the mandible can be considered
to be pulled anteromedially.

As previously mentioned, there have been numer-
ous reports stating that the various muscle bundles
from the temporalis, the zygomaticomandibularis,
and the masseter are attached to the articular disc, in
addition, to the muscle bundle from the upper head of
the lateral pterygoid muscle. According to the present
findings, all of the muscles and the muscle bundles
close to the articular disc could pass to and attach to
the disc (Fig. 5). In general, the medial muscle fibers
are attached more tightly than the lateral muscle
fibers. Based on the position of the attachment, the
lateral fibers were thought to pull the disc anteriorly.
In a precise analysis, the muscle fibers attached to
the condylar process of the mandible were markedly
thicker than the muscle fibers attached to the disc
(Usui et al., 2008). The direction differed between the
fibers attached to the condylar process and the fibers
attached to the disc; the fibers to the condylar pro-
cess ran posterolaterally to meet the bone, and those
to the disc ran posteriorly to reach the disc.

Osborn (1989, 1993) proposed a biomechanical
model of the human temporomandibular joint. In this
model, the condyle disc complex slides along the artic-
ular eminence during opening. Yatabe et al. (1995)
indicated that the condyle has closer contact with the
articular eminence during opening than during clos-
ing. Huddleston Slater et al. (1999) showed that in
the loaded condition during closing movements, the
intra-articular distance within the temporomandibular
joint is reduced. It is thus very important that the
articular disc and the condyle move together as a
functional complex during jaw movements. However,
in this study, the differences between the directions
of the muscle fibers to the disc and the condyle are dem-
strated, as are the variations of the muscle fibers
which inserted at the disc. These differences could
affect the functions of the complex in lateral move-
ments.
ments during jaw closing and opening. Careful physiological analyses should be carried out to define the disc functions during the jaw movements.

Previous studies suggested that the fibers attached to the disc represented muscle or connective tissue (Bravetti et al., 2004). Eisler (1910) claimed that the deep muscle fibers of the masseter attach to the disc and prevent disc movement. Merida-Velasco et al. (1993) noted that the muscle bundles of the temporalis and masseter attached to the disc and, in part, work against the anteromedial pull of the upper head of the lateral pterygoid muscle during closing. On the other hand, Schmolke (1994) indicated the possibility of the temporal muscle and the masseter, via their muscle spindles, monitoring the positional relationship among the various structures impinging on the temporomandibular joint. Based on the present results of gross anatomical investigation of the precise muscle attachments to the disc, however, it is obvious that all of the muscle fibers work to pull the disc. The difference in fiber volume observed among individuals is thought to explain variations in movement of the temporomandibular joint.

REFERENCES


