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# Morphological classification of the temporalis muscle attachment on the coronoid process

조선대학교 대학원

치의학과

김 태 훈

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근육돌기에 부착된 관자근의 형태학적 분석

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치의학과

김 태 훈

# 김태훈의 박사학위 논문을 인준함

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(지도교수 : 김 홍 중)

관자근은 아래관자선에서 일어나 근육돌기에 닿는 단일층으로 아래턱뼈의 거상 및 후퇴에 주요한 작용을 하는 것으로 알려져 있다. 이러한 관자근은 최근 아래이틀신경의 마취, 셋째큰어금니의 발치 및 턱관절 정복을 위한 기준점으로 이용되고, 또한 관자근 힘줄염 치료를 위한 직접 주사와 같이 다양한 임상 치료에 적용되고 있다. 이러한 관자근이 닿는곳에서 근육돌기를 넘어 얕은힘줄과 깊은힘줄로 나뉘어 어금니뒤삼각과 셋째큰어금니 후방까지 연장되어 내려온다는 보고가 있어, 아래턱 어금니부위에서 시술 시 주의가 요구되고 있다. 이에 따라 본 연구에서는 한국인에서 관자근을 재조명하여 근육섬유에 따라 구분하여 살펴보고, 나누어진 각각 근육섬유의 닿는곳의 위치를 계측하여 해부학적 특징과 그 임상적 의의를 살펴보고자 한다.

고정된 한국인 시신 26구를 사용하여 관자근이 일어나는 전체 부분을 확인한 후, 전체 관자근이 부착된 아래턱뼈를 얻어 조심스럽게 해부하였다. 얻어진 관자근을 근육섬유의 주행 방향에 따라 구분하고. 나누어진 부분을 스케치하였다. 각 부분이 근육돌기에 닿는곳의 위치를 자세히 살펴보기 위하여 뼈 표지점을 기준으로 하여 계측하였다.

모든 표본에서 관자근은 통상적으로 알려진 것 보다 넓은 부위에서 닿는 두 개의

뚜렷한 힘줄을 가졌으며, 이러한 힘줄에 따라 두 부분으로 구분되었다. 관자근의 얕은부분은 일반적으로 알려진 넓은 부채꼴의 근육으로, 턱뼈가지의 앞모서리를 따라 아래안쪽으로 달려 얕은힘줄이 되어 어금니뒤삼각의 가쪽경계를 만들었다. 관자근의 깊은부분은 좁고 긴 직사각형의 근육으로, 뒤가쪽으로 달려 근육돌기 안쪽부분의 관자능선에 닿았다. 이후 관자능선의 혀쪽모서리를 따라 더 내려와 깊은힘줄이 되어 어금니뒤삼각의 안쪽경계를 만들었다.

이러한 근육돌기 부착을 기준으로 한 관자근 닿는곳의 형태 및 위치에 관한 연구 결과는 아래턱 어금니부위에서 외과적 시술 및 턱관절 정복 시 유용한 해부학적 자료를 제공해 줄 수 있을 것으로 사료된다.

**중심어:** 관자근, 근육돌기, 얕은힘줄, 깊은힘줄

# I. INTRODUCTION

The temporalis muscle is a large fan shaped muscle that originates from the inferior temporal line and temporal fossa and inserts into the coronoid process, and one of the masticatory muscles that perform elevation, retraction, and unilateral contraction of the mandible [5, 12, 20]. In addition to these strong mastication function, it is used as a landmark for inferior alveolar nerve block anesthesia, third molar extraction, and determination of the posterior denture flange, and is also used for direct temporalis tendon injection and temporalis tendon transfer in plastic surgery [2, 4, 16, 17, 18]. For these various clinical applications, the temporalis muscle has emerged its morphology and functional anatomy including the temporalis tendon.

The temporalis muscle is described or illustrated in many texts and atlas that originates at a wide attachment site, converges to the form of tendon, and inserts into a narrow site of the coronoid process [2, 5, 20]. However, previous research on the development of temporalis muscle in the human fetus, it was extended inferiorly to 2 muscle fascicles in the coronoid process; one inserts into the anterior border of the mandibular ramus and the other inserts into the medial surface of the ramus. [15]. Another study on temporalis tendon confirmed two tendons, superficial tendon attached to anterior border of mandibular ramus and deep tendon attached to temporal crest of medial surface of ramus [9, 12, 14]. Benninger et al. [2] suggested that the distal attachment of the tendon of the temporalis muscle should be marked and illustrated to the retromolar fossa beyond the coronoid process to be accurately represented.

Various studies have been carried out recently to divide a layer or part of temporalis muscle, due to a broad and thick morphology and a strong mandibular elevation action of this

muscle. The sphenomandibularis named by Dunn et al. [6], which arises from the infratemporal surface and crest of the greater wing of the sphenoid bone inside the pterygopalatine fossa, makes a deep tendon, and inserts along the entire length of the temporal crest, was identified as the deep layer or medial portion of the temporalis muscle. As a result, the temporalis muscle known as large fan-shaped muscle could become a superficial layer or lateral portion and distinct from the inner deep layer [8, 21]. In another study, it was divided into three parts: superficial, deep, and zygomatic parts depending on whether the zygomaticomandibularis, which originates from the internal layer of the deep temporal fascia above the zygomatic arch and inserts into the outer surface of the superficial temporalis tendon and the coronoid process, and the sphenomandibularis were involved [10, 22]. The other studies divided it into three parts: orbital (or anterior, vertical fiber), temporal (middle or oblique fiber), and posterior (horizontal fiber) parts according to muscle direction and electromyographic analysis [7, 12]. Thus, each researcher divided the temporalis muscle into different parts depending on the criteria of evaluation.

An anatomical structure is determined by what it functions according to its morphology [21]. And in the cadaver dissection for this preliminary study, the temporalis muscle had a much wider insertion site than the text books. Therefore, the aims of this study were to classify the parts of the temporalis muscle according to the muscle fascicle forming the terminal tendon by identifying its origin and insertion and to evaluate the function of each part in Korean. In addition, it was to elucidate where each part of the temporalis muscle fascicle attaches to coronoid process.

# II. MATERIALS AND METHODS

This study was dissected the temporalis muscle in 26 embalmed cadavers that had been donated for educational purposes to the Department of Anatomy, Chosun University School of Medicine. They were composed of 18 males and 8 females, and ranged in death age from 40 to 97 years with a mean age of 64.9 years. It was performed 26 specimens (right 14, left 12) that did not damaged the temporalis muscle and the mandible regardless of tooth condition. This study was performed as follow the Declaration of Helsinki on medical protocol and ethics.

To elucidate the origin and the tendinous insertion to the coronoid process of the temporalis muscle, at first, it were removed the skin and subcutaneous tissues of each hemi-face and revealed the superficial temporal fascia and the masseter muscle. Using the results of Schön Ybarra and Bauer [21] and Geers et al. [8] as a guide, it was removed the masseter muscle and the zygomatic arch in order, reconfirmed the origin of the temporalis muscle, and acquired the mandible blocks with whole temporalis muscle. It was removed the retromolar pad by the frontal approach without damaging the temporal tendon and carefully dissected using a surgical microscope (OPMI-FC, Carl Zeiss, Oberkochen, Germany). After removal of the superficial and deep temporal fasciae, it was dissected in consideration of the direction of the muscle fascicle, along the deep tendon that inserted into internal surface of the mandibular ramus and the superficial tendon attached into its external surface. Each divided part was sketched and measured.

In order to analyze the portion of each part attached to the coronoid process, it were measured 7 items including the lowest point and the posterior point of the two tendons based on the bony landmark such as the inferior border of mandible, the lingula, and the mandibular

notch using a digital caliper (Mitutoyo, Kawasaki, Japan) (Fig. 1). Two observers were measured twice on different days by the same criteria.

Statistical analysis was performed using SPSS 22.0 (SPSS, Chicago, IL, USA). Using one-way ANOVA, it were examined significance differences at both between-observers ($p>0.05$) and gender ($p>0.05$), also according to height from the inferior border of the mandible to at each measurement point, and then evaluated with a post-hoc comparison on Scheeffe. No distinction was made with regard to age, laterality, and teeth condition. All measurements are presented as mean±SD values, and the significance level was set at $p<0.05$.

# III. RESULTS

The temporalis muscle was inserted into two strong tendons that superficial and deep on the outer and inner sides of the coronoid process (Fig. 2). As a result of dissection of muscle fascicle based on these two tendons, it was divided into two parts, a widely recognized superficial part of the temporalis muscle forming superficial tendon and a deep part of the temporalis muscle forming deep tendon. However, these two parts were clearly distinguished in the anterior direction, but were mixed with muscle fibers in the posterior direction.

The superficial part of the temporalis muscle was a large fan shaped muscle as described as the temporalis muscle in the text and atlas, originated in the inferior temporal line and temporal fossa, descended into the superficial tendon medially, and inserted at the apex, anterior and posterior margins, and the outer and inner surfaces of the coronoid process (Fig. 3 and 5). These superficial tendons were descended to the external oblique line along the anterior border of the mandibular ramus, stopped close to the third molar, and made a lateral boundary of the retromolar triangle on the buccal side. In addition, these tendons stopped at mean height of 3.29 ± 0.55 cm from the inferior border of mandible at the anterior side, which was slightly below the lingula (Table 1), and stopped anteriorly at mean of 0.33 ± 0.15 cm from the mandibular notch at the postero-superior side.

The deep part of the temporalis muscle, like the result of Schön Ybarra and Bauer [21] and Geers et al. [8], was located on the medial side of the superficial part, arose from the anterior and posterior ridge of the pyramidal shaped process on the infratemporal crest of the greater wing of the sphenoid bone inside the anterior roof of infratemporal fossa and the pterygopalatine fossa, and descended slightly postero-laterally as opposed to the superficial part (Fig. 4 and 5). This was narrow and long rectangular shaped muscle, formed the deep

tendon, and inserted into the inner surface of the coronoid process below the insertion area of superficial part. These deep tendon ran vertically along the lingual margin of the temporal crest and made a medial boundary of the retromolar triangle on lingual side. In addition, these tendons stopped at mean height of 3.05±0.36 cm from the inferior border of mandible at the anterior side, which descended closer to the third molar lower than the superficial tendon (Table 1). And it had mean width of 1.46±0.41 cm (Table 2) and stopped ahead of the lingula at mean height of 4.20±0.49 cm from the inferior border of mandible at the posterior side. These two tendons were separated at mean height of 4.84 ± 0.74 cm from the inferior border of mandible, where was higher than the end point of each tendon, and made a retromolar fossa where the minor salivary gland and the retromolar pad are placed.

In addition to these 2 parts of the temporalis muscle, zygomaticomandibularis did not form the main strong tendon but appeared all cadavers in the outermost layer (Fig. 5). This was a small thin fan-shaped muscle that arose from the medial side of the deep temporal fascia, descended antero-medially, and intermingled with the superficial tendon. It inserted into the superior border of the mandibular notch and the outer surface of the coronoid process, and stopped posteriorly at mean of 0.14±0.38cm from the mandibular notch, covered the superficial part at the posterior side. Also, it fused laterally with the deep part of masseter muscle at the postero-inferior side.

# IV. DISCUSSION

In recent studies, the temporalis muscle was divided into two layers or three parts to investigate its function and clinical correlations, by rebuttal of the classic description that is composed of a single layer which occurs in the temporal line of the parietal bone and attaches to the coronoid process [8, 10, 13, 21, 22]. Since the origin and insertion of the muscle determine the vector of force [21], we classified the temporalis muscle according to the muscle fascicle forming the terminal tendon.

In this study, the temporalis muscle was stopped by 2 strong terminal tendons and divided into superficial and deep parts, in agreement with Schön Ybarra and Bauer [21] and Geers et al. [8]. The superficial part of the temporalis muscle coincided with what is commonly known as the temporalis muscle. It formed the superficial tendon, was down along the anterior border of the mandibular ramus to the lingula level, and made the lateral border of the retromolar triangle. The buccal nerve passed through the superficial tendon at this location, so, care should be taken when the incision is made at the retromolar area [11]. And this superficial part was the main part of the whole temporalis muscle as a large fan-shaped muscle. According to electromyographic analysis, the orientation of the temporalis muscle was divided into anterior, middle, and posterior parts, and each part made the mandible protrusion, rotation, and retrusion, respectively [3, 7, 12]. And the orientation of its fibers was medially oriented, so it is thought to work on unilateral contraction on the working side. This part was decreased its dimension with age [19], so it need to further investigate the effect of tooth loss on dimension of temporalis muscle and mastication.

The deep belly or medial portion of temporalis muscle located on the medial side of its main portion that originates the pyramidal shaped process on the infratemporal surface of the

greater wing of the sphenoid bone and inserts into the temporal crest of medial surface of ramus [8, 21]. Dunn et al. [6] concluded it as an independent muscle distinct from the classical temporalis muscle and named the sphenomanibularis. With the results of Schön Ybarra and Bauer [21] and Geers et al. [8], in this study, the deep part of the temporalis muscle was covered with the deep temporal fascia with the superficial part, and two parts were intermingled at the posterior side without any special structure dividing them. Therefore, it is reasonable to regard the deep part as a single muscular complex with the superficial part.

However, the deep part had distinct origin and insertion that distinguish it from the superficial part, and its muscle fiber descended slightly postero-laterally as opposed to the superficial part. So it is thought to work on unilateral contraction on the balancing side as well as making the mandible elevation and protrusion. On the histologic study, it also included numerous nervous structures similar to the superior belly of the lateral pterygoid muscle rather than the superficial part [8]. This means that the lateral movement is much more complicated and delicate than the movement of opening and closing the mouth, so, it is necessary to understand the movement by separating the deep part from the superficial part. In addition, further studies are needed to examine the distribution and function of the 2 parts of the temporalis muscle in detail.

In previous studies, the deep part was an average of 5.2 cm in length and 1.4 cm in width, ended inferior to the superficial part in the anterior side and ahead of the mandibular foramen in the posterior side [6, 8, 9, 18]. In this study, the deep part was also vertically rectangular shaped muscle with an average of a 1.4 cm in width and attached to the medial side of the ramus under the superficial tendon. It became a deep tendon, made a medial boundary of retromolar triangle, and stopped at a height of about 3 cm from the inferior border of mandible. This results of the temporalis tendon would be used as reference landmarks for

surgical procedures in the retromolar region, including determination of the posterior denture flange and reduction of TMJ dislocations. And it also could provide useful data for manual palpation during a direct temporalis tendon injection.

In this study, besides these 2 parts of the temporalis muscle, the zygomaticomandibularis was found under the deep temporal fascia in all cadavers consistent with previous studies, but did not form the main strong tendon [7, 10]. Although some recent study included this muscle as the outermost layer of the temporalis muscle [22], it seems difficult to consider this muscle as a part of the temporalis muscle. Because the masseter nerve runs between the zygomaticomandibularis and the masseter muscle, and some muscle fibers of the zygomaticomandibularis intermingles with the deep layer of the masseter muscle [1, 7, 10, 23]. And these research results are expected to provide the anatomical knowledge on morphology of the temporalis muscle related to its insertion on the coronoid process during the surgical procedure such as extraction, anesthesia, and TMJ reduction at the retromolar region.

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# VI. FIGURES

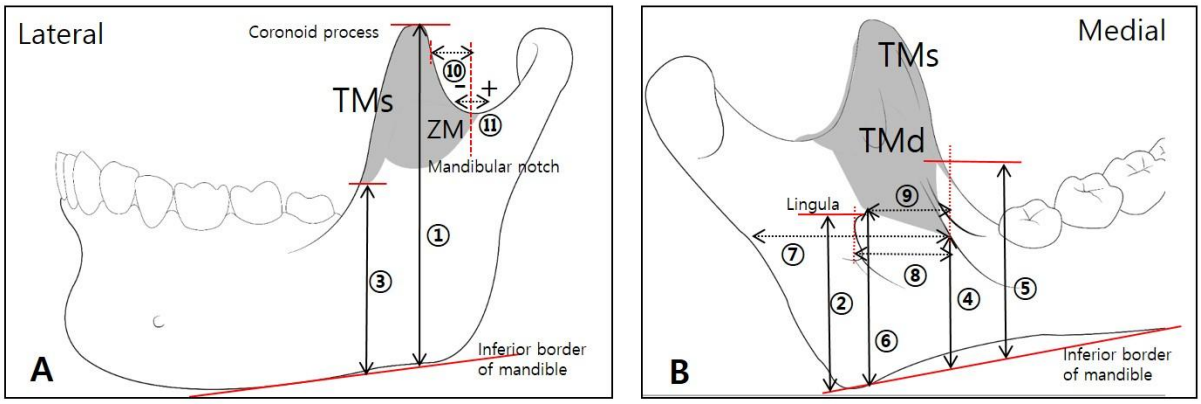


**Fig. 1. Diagram showing the parameters that two separated parts of the temporalis muscle attached to the coronoid process were measured based on the bony landmarks.** ①, the height of apex of the coronoid process from the inferior border of the mandible; ②, the height of the lingula from the inferior border of the mandible; ③, the height of the ending point of the TMs (superficial part of the temporalis muscle) from the inferior border of the mandible; ④, the height of the ending point of the TMd (deep part of the temporalis muscle) from the inferior border of the mandible; ⑤, the height of the separating point of two parts from the inferior border of the mandible; ⑥, the height of the medial ending point of the TMd; ⑦, the width of the mandibular ramus on the level of the ending point of the TMd ; ⑧, the width of the lingula on the level of the ending point of the TMd; ⑨, the width of the TMd; ⑩, the distance between the posterior ending point of the TMs and the mandibular notch; ⑪, the distance between the posterior ending point of the ZM (zygomaticomandibularis) and the mandibular notch.

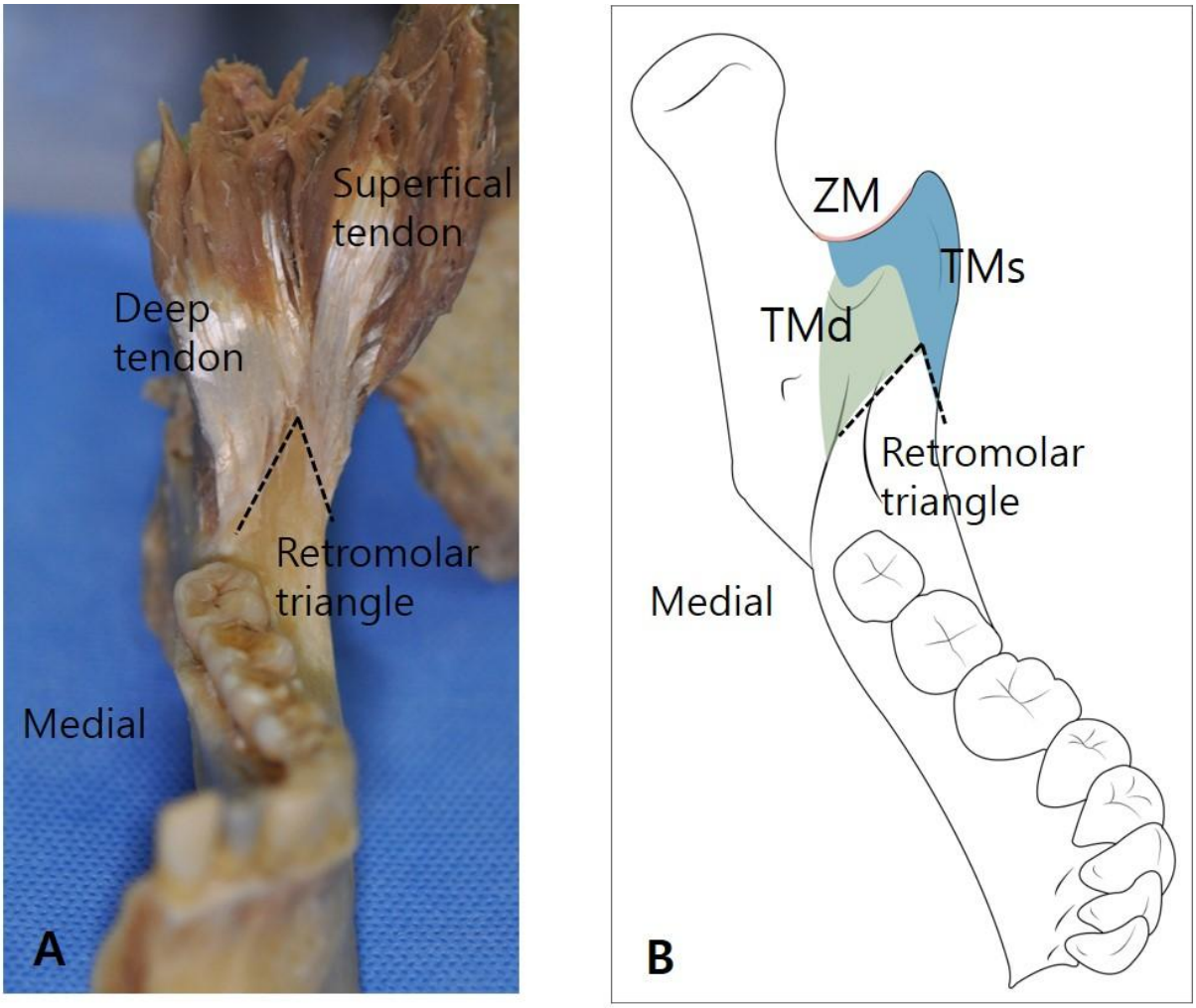


**Fig. 2. Photographs present that the distinct two terminal tendon of the temporalis muscle made a boundary of both sides of the retromolar triangle.**

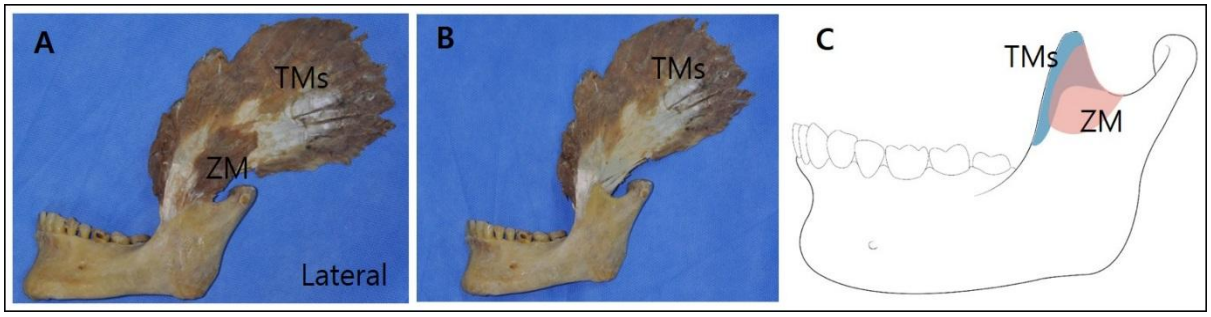


**Fig. 3. Photographs showing the dimension of the TMs and ZM attached into the coronoid process on the lateral side of the mandible.** The blue color indicates the dimension of the TMs and the red color indicates the dimension of the ZM.

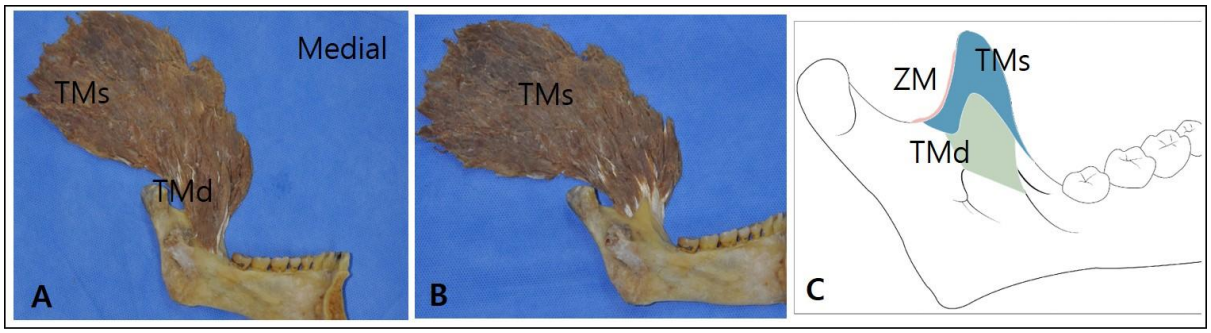


**Fig. 4. Photographs showing the dimension of the TMs and TMd attached into the coronoid process on the medial side of the mandible.** The green color indicates the dimension of the TMd. In this side, the dimension of the ZM could be not actually observable, but it is labeled on the diagram.

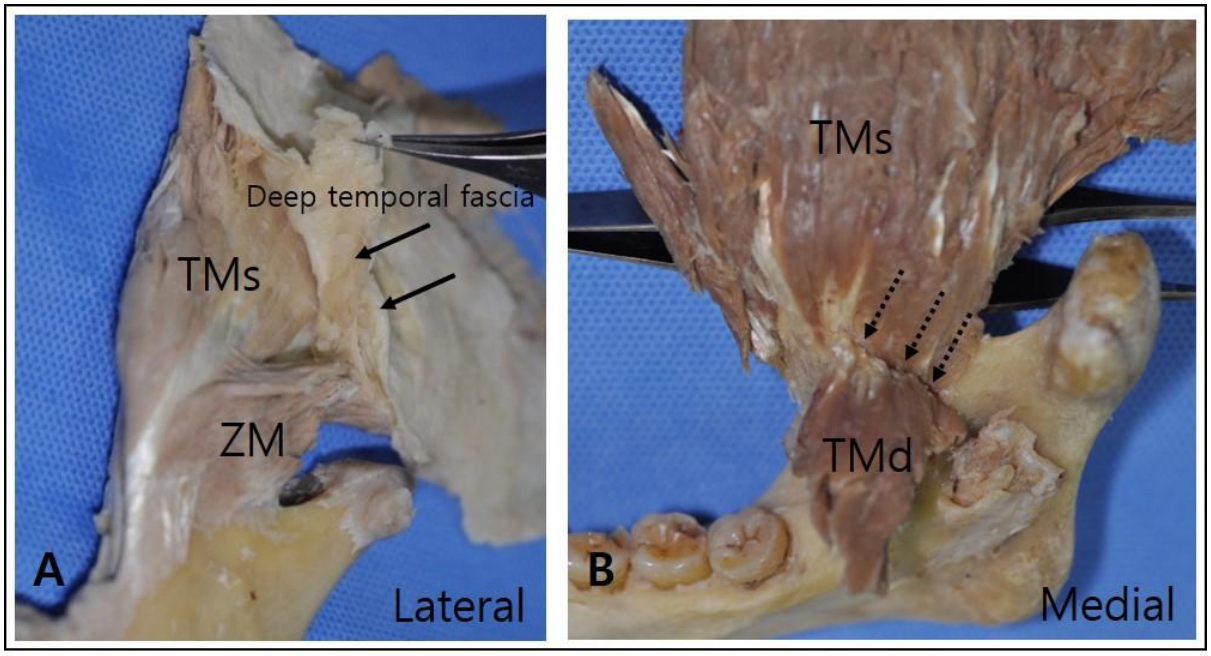


**Fig. 5. Photographs showing the dissection to subdivide the temporalis muscle.** The solid arrows (A) indicate that the ZM originated from the internal layer of the deep temporal fascia. The broken arrows (B) indicate that the TMs and TMd were clearly distinguished in the anterior direction, but were mixed with muscle fibers in the posterior direction.

# VII. TABLES

**Table 1. Height from the inferior border of the mandible to each measurement point**

| | Minimum | Maximum | Mean±SD | Ratio |
|---|---|---|---|---|
| **Apex of coronoid process** | 5.30 | 8.45 | 6.51±0.80 | 1 |
| **Lingula** | 2.13 | 4.30 | 3.42±0.64 | 0.52 |
| **Ending point of TMs** | 2.20 | 4.32 | 3.29±0.55 | 0.50 |
| **Ending point of TMd** | 2.51 | 3.65 | 3.05±0.36 | 0.47 |
| **Separating point of TMs and TMd** | 3.58 | 6.67 | 4.84±0.74 | 0.74 |
| **Medial ending point of TMd** | 3.07 | 5.06 | 4.20±0.49 | 0.65 |

Abbreviations: TMs, superficial part of the temporalis muscle; TMd, deep part of the temporalis muscle. The data (in cm) are mean±SD values.

**Table 2. Width of each measurement item on the level of the ending point of the TM**

| | Minimum | Maximum | Mean±SD | Ratio |
|---|---|---|---|---|
| **Mandibular ramus** | 2.94 | 3.91 | 3.43±0.29 | 1 |
| **Lingula** | 0.66 | 2.56 | 1.51±0.47 | 0.44 |
| **TMd** | 0.77 | 2.48 | 1.46±0.41 | 0.43 |

The data (in cm) are mean±SD values.