

**An anatomic study on the insertion
of the zygomaticus major muscle in
human
focused on the muscle
arrangement at the mouth corner**

Kyoung-Sub Shim, D.D.S., M.S.

**Department of Dentistry
The Graduate School, Yonsei University**

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of the zygomaticus major muscle in
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arrangement at the mouth corner**

Directed by Professor Hee-Jin Kim, D.D.S., Ph.D.

**The Doctoral Dissertation
submitted to the Department of Dentistry,
the Graduate School of Yonsei University
in partial fulfillment of the requirements for the
degree of
Doctor of Philosophy.**

Kyoung-Sub Shim, D.D.S., M.S.

June 2005

**This certifies that the Doctoral
Dissertation
of Kyoung-Sub Shim is approved.**

Thesis Supervisor : **Prof. Hee-Jin Kim**

Thesis Committee Member : **Prof. Han-Sung Jung**

Thesis Committee Member : **Prof. Syng-Il Lee**

Thesis Committee Member : **Prof. Yong-Chul Bae**

Thesis Committee Member : **Prof. Ki-Seok Koh**

The Graduate School
Yonsei University

June 2005

Acknowledgements

대학 졸업 25년만에 귀한 목표 하나를 달성합니다. 또한 뒤늦게 이룬 성과라 더욱더 감회가 큼니다.

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ABSTRACT

An anatomic study on the insertion of the zygomaticus major muscle in human focused on the muscle arrangement at the mouth corner

Kyoung-Sub Shim, D.D.S., M.S.

Department of Dentistry, The Graduate School, Yonsei University
(Directed by Professor Hee-Jin Kim, D.D.S., Ph.D.)

The aim of this study were to clarify the arrangement of the zygomaticus major (ZMj) through a topographic examination, and to evaluate the anatomical variations in the insertion of the ZMj in relation to the facial vessels in the peri-oral region. From 70 dissections, the bifid ZMj (40%) was observed and its attachment to the other facial musculatures is described. At the peri-oral region of the dissected specimens, the anatomical aspects of the muscular arrangement and attachment of the ZMj were classified into four categories: type I, the superficial muscle band of the ZMj is blended and interlaced with the levator anguli oris (LAO), whereas the fibers of the deep muscle band blend into the buccinator and the LAO passing deep to the LAO was the most common encountered (54.3%). It was found that the insertion of the ZMj was divided into superficial and deep bands (42 cases in type I and IV, 60%), as well as into three layers of superficial, middle and deep fibers (17 cases in type II, 24.3%). The others were cases where the ZMj was inserted deep into the LAO as a single muscle band (11 cases in type III, 15.7%). It was also observed that the topographic aspect of the facial artery passed through the

separate muscle bands of the ZMj in 42.9%. The arrangement and insertion patterns of the ZMj in this study are expected to provide the critical information for the surgical planning and procedure for facial reanimation surgery.

Key words: zygomaticus major, levator anguli oris, facial expression, orbicularis oris, depressor anguli oris

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I. INTRODUCTION

The facial musculature has attracted considerable attention in the publications because the muscles participating in the emotional expression show individual variations. Nevertheless, they have been considered that the anatomic knowledge and variations in these structures were already well described in the literature and in the anatomy textbooks. Recently, precise knowledge of the facial expression based on the anatomy of the peri-oral facial musculatures has become more important in the surgical field as a result of the increased patients' desires and the advances in clinical techniques. For these reasons, recognition of the facial expression mechanism is very important when evaluating patients for aesthetic dentistry, orthodontics, cosmetic and reconstructive surgery.

The facial expression is classified into 6 categories; sadness, anger, joy, fear, disgust, and surprise.¹ These dramatic changes in facial expression are

remarkable in the region around the eye and lip movement as a result of a contraction of the facial muscle. In particular, the change in the shape of the lip during an expression is performed by the lip movers. These muscles are composed of four elevators, four depressors and two laterals on each mouth corner.²

In the peri-oral region, the muscles for the facial expression are arranged in four layers, based on their origins.³ The individual muscles are arranged in the superficial (first, second and third) layer and the deepest (fourth) layer, and it has been documented that the zygomatic major muscle (Zmj) is located in the superficial layer. The deepest fourth layer is composed of the levator anguli oris (LAO), mentalis and buccinator muscle.

Among these peri-oral musculatures, the Zmj plays an important role in the facial expression and the topographic anatomy of the ZMj muscle has been described in previous publications. However, except for few publications,^{3,4,5} it has generally been reported that the ZMj is located superficially among the peri-oral musculatures even in most anatomy textbooks.^{6,7,8} In addition, it was reported that the Zmj is always situated above the LAO in most anatomy atlases and illustrations.^{9,10,11,12} However, it can be observed that a part of the ZMj muscle fibers is commonly located deep in the LAO and is inserted into some peri-oral musculatures during a detailed dissection.

The aim of this study was to clarify the arrangement of the ZMj in the peri-oral region through a topographic examination followed by a detail dissection. An additional aim of this study was to demonstrate the anatomical variations in the insertion of the ZMj as well as its relationship with the facial

vessels, thereby providing the critical data for understanding the functional aspects related to the human facial expression.

II. MATERIALS AND METHODS

Seventy embalmed and fresh adult hemi-faces from cadavers (37 males, 32 females; average age 67.4 years) were used in this study. Among the specimens, 59 cases were Korean and 11 cases were French (from University of Lille II, Lille, France). In 10 specimens, latex (Neophrene, LOT No. 307L146, DuPont Co., France) with a red coloring agent (colorant universal, Castorama Co., France) was injected prior to dissection in order to observe the topographic relationship between the facial muscles and the course of the facial artery.

The skin and subcutaneous tissue of the face were removed from the lower eyelid to the inferior margin of the mandible. A detailed dissection was performed on all specimens with the extreme care being taken not to damage the underlying muscles, nerves and blood vessels. Special attention was also paid to the precise site of origin, course, and attachment of the peri-oral musculatures. The dissection was performed under a surgical microscope (Carl Zeiss, Germany) for the purpose of further microdissections on the insertion of the ZMj.

In order to examine the attachment of the ZMj and to clarify the interlacing patterns with other peri-oral musculatures, the ZMj was cut and retracted prior to a further dissection at the insertion area of the ZMj in every specimen. After a detail dissection in the modiolar region, the ZMj insertion en bloc was removed, which included the ZMj, the LAO, the orbicularis oris, the depressor anguli oris, a part of the lip and the facial vessels distributed in the facial

musculatures.

No distinction was made between male and female cadavers. However, the laterality on the muscle variations as well as the muscular insertion of the ZMj was observed with regard to the left or right of all the specimens. All photographs and diagrams in this article were of structures viewed from the left side of the face.

III. RESULTS

1. General description of the zygomaticus major muscle

The ZMj muscle was observed in all cases (Fig. 1A). As a muscular variant, a bifid ZMj (double zygomaticus major muscle) was observed in 28 cases (40.0%). Although the ZMj originated from the zygomatic bone as a single muscular band, the main muscle band was divided into two separate muscle fibers (superior and inferior fibers) at the infrazygomatic region superficial to the buccal fat pad (Fig. 1B). In each case of a bifid ZMj, the superior muscle fibers were larger and wider than the inferior fibers. The inferior muscle fibers were attached to and inserted into the other peri-oral musculatures below the plane formed between the bilateral cheilion points. There were 20 cases (71.4%) among 28 specimens of a bifid ZMj with the bilateral bifid Zmj in both sides.

In the 25 cases with a bifid ZMj (89.3%), the inferior muscle fibers were attached to the superficial and deep layers of the depressor anguli oris and risorius muscle. However, in 3 cases, the inferior muscle fibers of the bifid ZMj were blended into the buccinator fascia (2 cases, 7.1%) and the fascia covering the buccal fat pad (1 case, 3.6%).

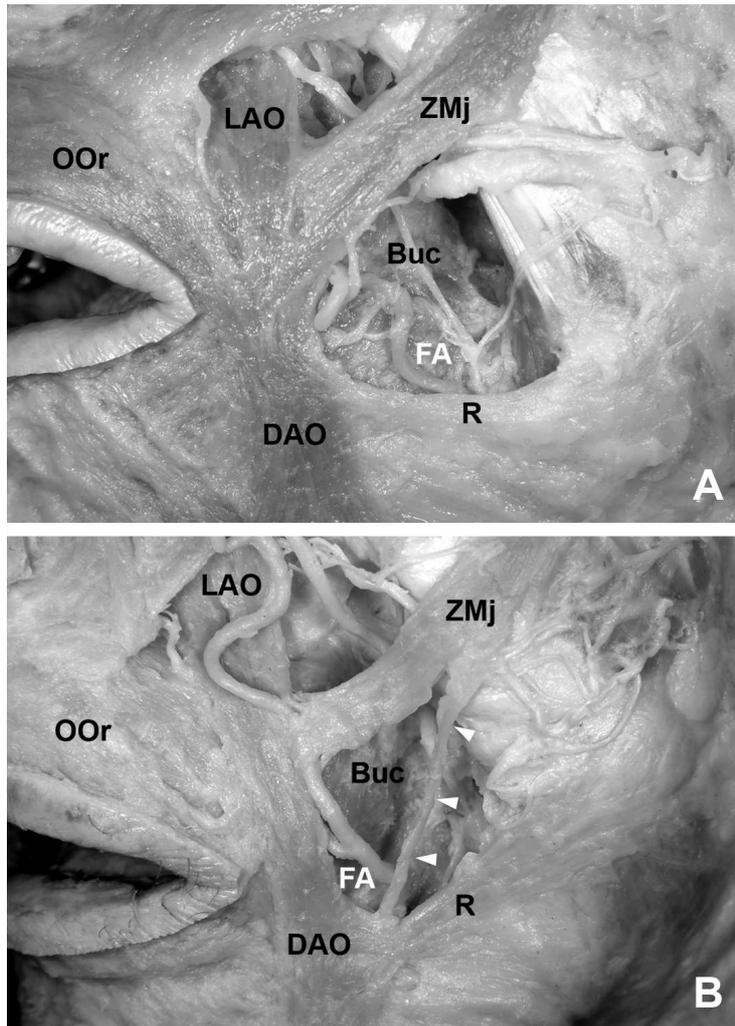


Fig. 1. Photographs showing the zygomaticus major (A) and the bifid zygomaticus major muscle (B) of the dissected specimens. In 60% of cases, the zygomaticus major (ZMj) was ran obliquely into the modiolar region as a single muscle band from the origin of the muscle. In contrast, a bifid ZMj was observed wherethe main muscle band was divided into two separate muscle fibers (superior and inferior fibers) at theinfrazygomatic region. The inferior muscle fibers of the bifid ZMj (arrow heads) is inserted into the risorius (R) and the depressor anguli oris (DAO) (OOr; orbicularis oris, LAO; levator anguli oris, Buc; buccinator, FA; facial artery).

2. Patterns of the arrangement and attachment of the zygomaticus major muscle

From the site of origin, the ZMj ran obliquely into the modiolar region. In this region, the ZMj, depressor anguli oris, orbicularis oris, risorius, and buccinator muscle were interdigitated forming a muscular node that was mutually associated with each other.

At the peri-oral region of the dissected specimens, the anatomical aspects of the muscular arrangement and attachment of the ZMj were classified into four categories with reference to the orbicularis oris and LAO (Figs. 2, 3). At the insertion of the ZMj, the muscle was divided into superficial and deep muscle bands (42 cases in type I and IV, 60%), into three layers comprised of superficial, middle and deep bands (17 cases in type II, 24.3%). The others were cases where the ZMj was inserted deep into the LAO as a single muscle band (11 cases in type III, 15.7%).

Type I was defined as the fibers of the superficial muscle band of the ZMj being blended and interlaced with the LAO, whereas the fibers of the deep muscle band blend into the buccinator and LAO passing deep to the LAO (38 cases, 54.3%) (Fig. 2A). The aspects of the interlacing of the superficial muscle band of the ZMj with the LAO showed a variety of patterns (Fig. 3). Around the insertion of the ZMj (modiolar region), the cases where the whole ZMj bifurcated into the superficial and deep muscle bands (11 cases) and those cases where the superficial muscle band bifurcated from the lower half of the ZMj (11 cases) were the most common. In these patterns, all the muscle fibers

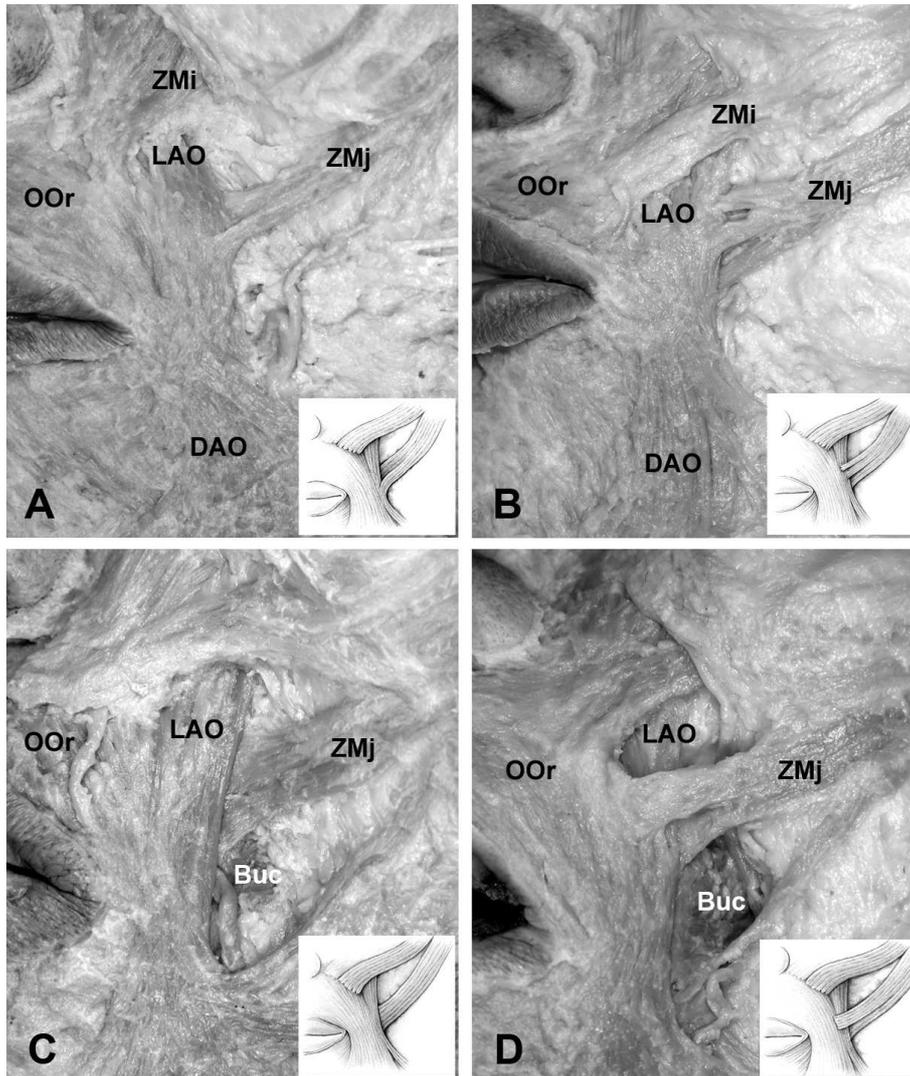


Fig. 2. Four patterns of the arrangement and attachment of the zygomaticus major muscle. Type I comprised of cases where the fibers of the superficial muscle band of the zygomaticus major (ZMj) blended and interlaced with the levator anguli oris (LAO), whereas the fibers of the deep muscle band blended into the buccinator and LAO passing deep to the LAO (A). Type II comprised of cases where the superficial bands of the ZMj blended into the superficial layer of the orbicularis oris and depressor anguli oris passing over the LAO, middle fibers interlaced into the part of

the LAO, and the deep fibers were blended and interlaced with the buccinator and LAO deep to the LAO (B). Type III comprised of cases where the only single muscle band of the ZMj passed deep into the LAO and all the fibers interlaced with the buccinator and LAO (C). Type IV comprised of cases where the ZMj was bifurcated into the superficial and deep muscle bands. The superficial fibers blended with the orbicularis oris and depressor anguli oris passing over the LAO and the fibers of the deep muscle band interlaced with a buccinator and LAO deep to the LAO (D) (OOr; orbicularis oris, Buc; buccinator, DAO; depressor anguli oris, ZMi; zygomaticus minor).

of the superficial band of the ZMj blended and interlaced with the LAO fibers. The other patterns were cases where the upper half (7 cases), the middle 1/3 (4 cases) and the lower 1/3 of the ZMj bifurcated from the ZMj, and these fibers were interlaced with the LAO (Fig. 3).

Type II comprised of those cases in which the ZMj was trifurcated into three muscle bands, superficial, middle and deep. This type was defined as the superficial fibers of the ZMj being blended into the superficial layer of the orbicularis oris and the depressor anguli oris passing over the LAO, the middle fibers interlacing into the part of the LAO, and the deep fibers blending and interlacing with the buccinator and LAO deep into the LAO. Seventeen cases of this type (24.3%) were found (Fig. 2B). The variety also existed on the muscle insertion in this category (Fig. 3).

Type III comprised of cases where the only a single muscle band of the ZMj passed deep to the LAO and all the fibers interlaced with the buccinator and LAO (11 cases, 15.7%) (Figs. 2C, 3). In this category, there were no muscle fibers interlacing the ZMj with the superficial part of the orbicularis oris and LAO. All the muscle fibers passing deep into the LAO were blended

and interlaced to the deep part of the orbicularis oris, depressor anguli oris and buccinator muscle.

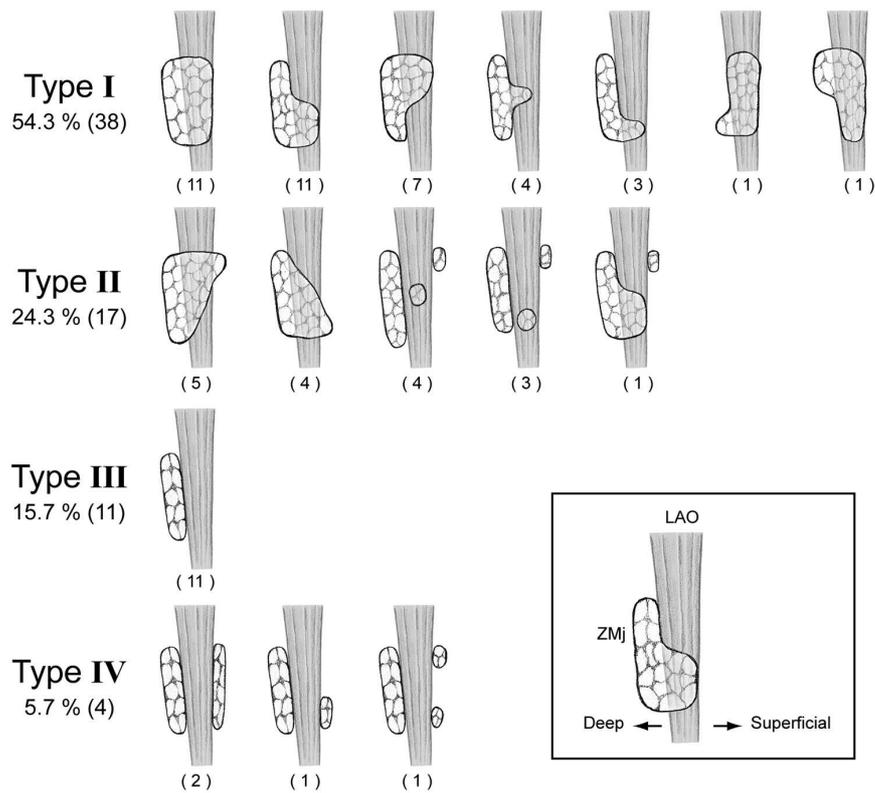


Fig. 3. Schematic diagram showing the arrangement and attachment patterns of the zygomaticus major muscle. These illustrations were based on the lateral aspects of the sagittal section through the lateral margin of the levator anguli oris (LAO) muscle on the left side of the dissected specimen. The interlacing patterns of the muscle bands of the zygomaticus major (ZMj) with the LAO showed a variety of patterns. The details are described in the results section. The numerals in the parentheses indicate the number of the cases.

Type IV comprised of cases where the ZMj was bifurcated into the superficial and deep muscle bands. The superficial fibers blended with the orbicularis oris and depressor anguli oris passing over the LAO and the fibers of the deep muscle band interlaced with the buccinator and LAO deep into the LAO (4 cases, 5.7%) (Fig. 2D). In this pattern, there were no fibers interlaced with LAO muscle fibers. Among this category, three interlacing patterns of the superficial fibers of the ZMj were examined (Fig. 3).

Most deep fibers of the ZMj were inserted and interlaced into the deep fibers of the orbicularis oris and depressor anguli oris muscle. In addition, the deep fibers were partially attached to the buccinator muscle and its fascia (Figs. 4, 5). When the deepest fibers originated from the upper portion of the ZMj, they passed superiorly and were interlaced with the maxillary portion of the buccinator and the deep portion of the orbicularis oris. In contrast, the deep fibers from the lower portion of the ZMj were blended with the muscle fibers of the mandibular portion of the buccinator and the depressor anguli oris (Fig. 5). In one specimen, it was observed that all the muscle fibers of the ZMj were attached and interlaced into the buccinator and its fascia only (Fig. 6).

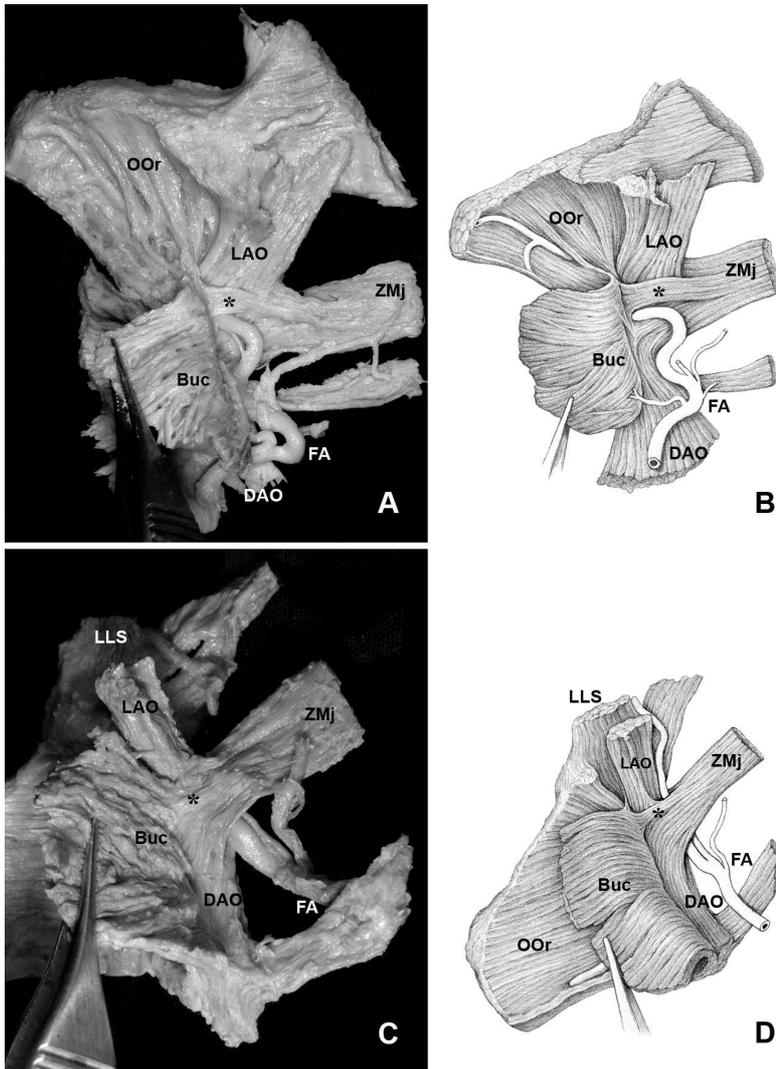


Fig. 4. Photographs (A and C) and the corresponding illustrations (B and D) of the dissections of the modiolar region from the posterior aspect of the specimen. The deep muscle bands (asterisk) of the zygomaticus major (ZMj) muscle were inserted and interlaced into the deep fibers of the orbicularis oris (OOr) and depressor anguli oris (DAO) muscle. The deep muscle bands (asterisk) were also partially attached to the buccinator (Buc) muscle and its fascia (LAO; levator anguli oris, LLS; levator labii superioris, FA; facial artery).

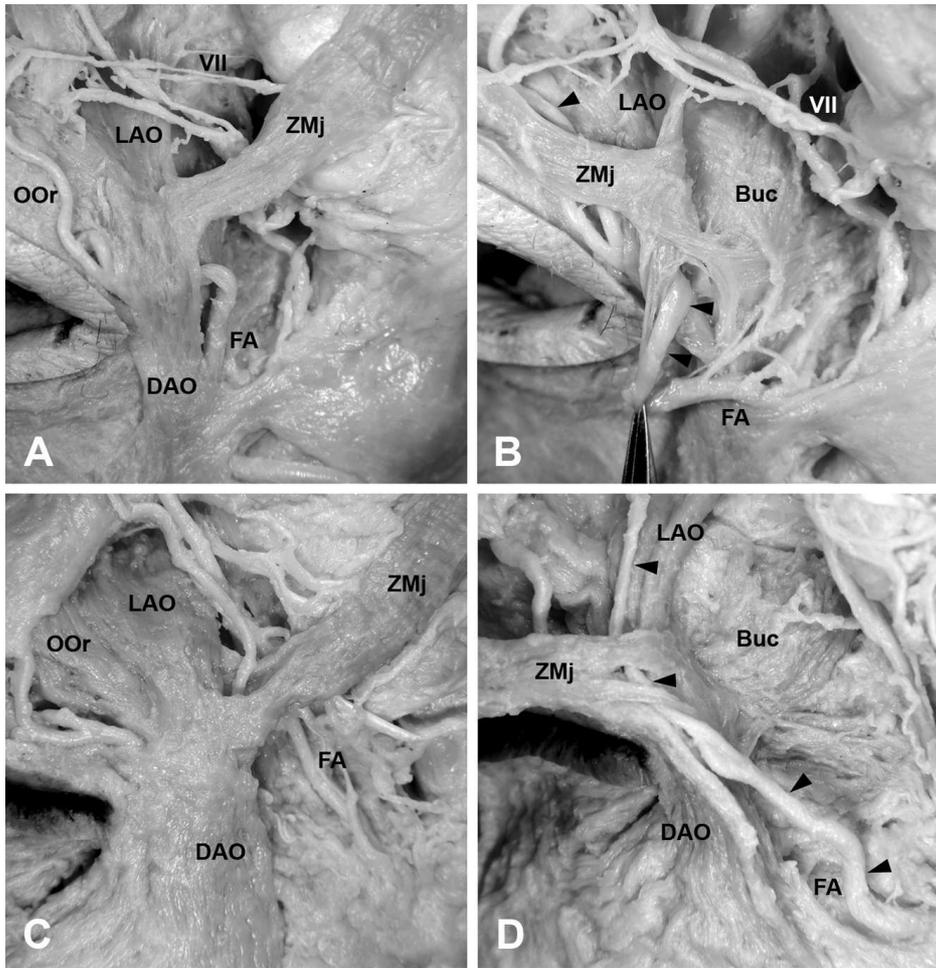


Fig. 5. The courses of the facial artery in the relation to the muscle bands of the zygomaticus major muscle. In 57.1% of specimens, the facial artery (FA) ran through the depressor anguli oris (DAO) and the orbicularis oris (OOr) muscle apart from the insertion area of the zygomaticus major (ZMj) muscle (A). In the deeper dissection after retracting the ZMj, the location and the course of the facial artery (arrowheads) are well shown (B). In contrast, the facial artery passed through the muscle bands of the ZMj in 42.9% of cases (C) and the running aspect of the facial artery within the muscle bands and insertion of the ZMj into the buccinator (Buc) was observed (D) (VII; facial nerve branches, LAO; levator anguli oris).

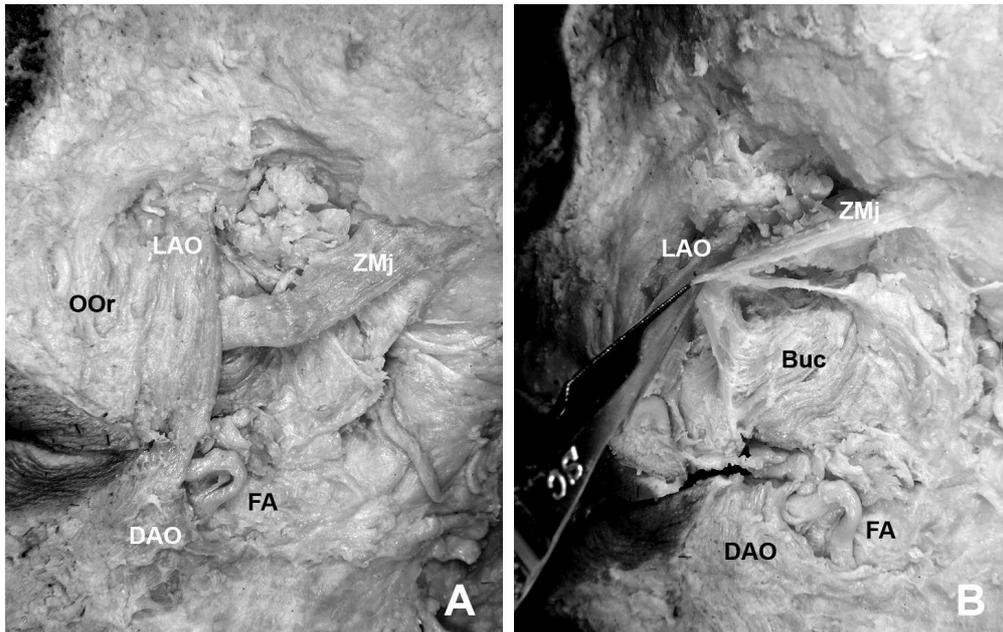


Fig. 6. Photographs showing a case of an abnormal muscle insertion of the zygomaticus major muscle. In these photographs, the muscle fibers of the the zygomaticus major (ZMj) passed deep into the levator anguli oris (A) and all the muscle fibers of the ZMj were attached and interlaced into the buccinator (Buc) and its fascia only (B) (OOr; orbicularis oris, LAO; levator anguli oris, DAO; depressor anguli oris, FA; facial artery).

IV. DISCUSSION

It is well known that the facial expression muscles have some structural variability in their size, shape and the occurrence of certain facial musculature.^{9,13,14,15} Among the facial musculatures around the lip, the ZMj appears to be an important muscle in the facial expression with the orbicularis oris. In particular, the ZMj originates from the lateral surface of the zygomatic bone and inserts obliquely into the mouth corner. In addition, it is responsible for pulling the lips upward and laterally to create a smile expression.

The ZMj is usually represented as a single muscular band. A bifid ZMj (double zygomaticus major muscle) is studied as an anatomical variant.^{14,15,16} In this study, the bifid ZMj was observed in 28 cases (40.0%), the occurrence of this variant was observed more frequently in males (17 cases, 60.7%) than in females (11 cases, 39.3%). From a previous study,^{14,15} the bifid ZMj was noted in 34.0% but there was a higher occurrence in females (65%).

The bifid ZMj was well discernible in most cases. The inferior muscle fibers were thinner and it bifurcated from the inferior aspect of the ZMj on the buccal fat pad at the infrazygomatic fossa. Even though there were few cases where it was difficult to distinguish between the risorius fibers and the inferior muscle fibers of the ZMj, the definition of the ZMj in this study was confined to within those cases where the muscle fibers continuously extended to the site where the muscle originated. The inferior muscle fibers of the bifid ZMj inserted into the inferior to the modiolar region and continued with the superficial or deep muscle fibers of the depressor anguli oris or the risorius in

most cases.

There were rare cases where the inferior muscle fibers of the ZMj blended into the buccinator fascia (2 cases) and the fascias covered the buccal fat pad (1 case). These abnormal insertions were regarded as an insertion into the dermis of the buccal skin, which may result in the formation of a cheek dimple.¹⁴ This study also tried to verify the aspect on the bilaterality of the bifid ZMj. Among the 18 individuals presenting with a bifid ZMj, 10 individuals (55.6%) showed bilaterality. In other words, such a high variation in the muscular morphology indicated a high variability in the facial expression.

The arrangement of the facial musculatures has been studied from many different perspectives. Among the factors studied, ultrasonic examinations,^{17,18,19,20} CT^{21,22,23} and MRI^{24,25} as well as gross and histological examinations have been performed.^{3,4,5,26,27,28,29} Through these studies, the anatomical and functional aspects of the peri-oral musculatures have been clarified.

Even in general anatomy textbooks,^{6,7,30,31,32,33,34} the detailed insertion pattern and arrangement of the peri-oral musculatures is not well described and it also incorrectly illustrated in most figures that the whole ZMj muscle fibers are located above the LAO. For these reasons, there has been some confusion in the literature as to the correct anatomical relationship of the ZMj relative to the LAO.

However, a detailed description of the arrangement and insertion of the ZMj is available in some papers.^{3,4,5} Lightoller⁴ reported a detailed description of the

facial musculatures, which differed from general textbooks in many anatomical viewpoints. In his publication, it was reported that "the insertion of the ZMj is divided into two separate portions, and the LAO passes between the two heads." This finding was also documented by Nairn⁵ and Freilinger *et al.*³

Despite the previous complete descriptions on the facial musculatures, these reports were only confined within the general explanation of the muscle insertion pattern based on several cadaver dissections. In this study, four insertion patterns of the ZMj were identified (Figs. 2, 3), which is similar to previous studies. These results explain the existence of the distinct muscle fibers of the ZMj, which pass below the LAO in every case. Such a finding indicates that the current anatomical description about the peri-oral muscle arrangement in the modiolar region should be reconsidered in anatomical aspects. According to our results, the anatomic relationship can be redefined. The deep muscle band of the ZMj is located in the deepest layer of the face along with the LAO and buccinator.

In contrast, the superficial muscle bands of the ZMj superficial to the LAO were thinner than the deep band and allowed the muscle fibers to interlace with the orbicularis oris, depressor anguli oris and also with the LAO. Based on these anatomical findings, it was predicted that the pulling action of the deep muscle band of the ZMj might be more dominant than the superficial muscle band.

Many studies have investigated the anatomy of the lip musculature and the smiling mechanism.^{4,5,14,15,28,35,36,37,38,39,40} With the viewpoint of the ZMj insertion, the detailed function in the facial expression can be assumed. In revealing the

smile animation of individuals, it is known that the major lip elevators, such as the levator labii superioris, LAO and ZMj contribute, and the ZMj participates in many cases of smile patterns.^{35,40}

As shown in this study, the ZMj inserted around the modiolar region and the muscle fibers were interlaced with the buccinator, LAO and orbicularis oris. Even though all these muscles converged and were interdigitated at the modiolar region, knowledge of the relationship between the deep muscle band of the ZMj and the buccinator is crucial in the understanding of facial animation. In every case, the main insertion of the deep muscle band of the ZMj was at the anterior margin of the buccinator and its fascia. This anatomical relationship provides the synchronous pulling of the anterior region of the buccinator with the corresponding buccal mucosa outward and upward to create the smile. The outward movement of the anterior margin of the buccinator and the contraction of the lip elevators naturally compress the cheek fat mass above the nasolabial fold, and this cheek mass becomes quite prominent.²⁵ These muscle actions also widen the nasal width due to the expansion of the midface contour followed by the muscle pulling upward and laterally.

In terms of the origin of the separate muscle bundles of the ZMj, Lightoller⁴ reported that "the superficial portion is derived chiefly from the lateral superficial fibers of the muscle, and the deep portion from the medial superficial and deep fibers." In this study, there was no case in accordance with Lightoller⁴ but various patterns were observed. Among these, 14 cases, where the ZMj fully bifurcated into the superficial and deep muscle bands

were found. The others were cases where the superficial muscle band derived from the medial aspect of the ZMj (20 cases), from the lateral aspect (20 cases), and from the medial and lateral aspects (5 cases). In 11 cases, there was no superficial muscle band of the ZMj (Fig. 3).

Precise knowledge of the topographic arrangement of the peri-oral musculatures is essential for the surgical planning and procedures such as the myoplasty or the free muscle transplantation. For the recreation of the personal natural appearances and preserving the function of the facial animation after surgical treatment, the new muscle or tendon needs to be attached to the peri-oral musculatures mainly below the LAO, ensuring the suturing with the buccinator during a surgical procedure. In addition, an understanding of the anatomical knowledge of the facial expression is important in treating facial paralysis. Furthermore, anatomical data on the muscular variation might make it possible to improve the results of surgical procedures.

V. CONCLUSION

In conclusion, based on the detailed dissection of the insertion of the ZMj, a bifid ZMj (40% of the specimen) and the arrangement of the peri-oral musculatures were observed. The insertion patterns of the ZMj were classified into 4 categories, and the existence of distinct muscle fibers of the ZMj passing deep to the LAO was confirmed in every case. It is concluded that the anatomical description needs to be modified so that the deep major portion of the ZMj can be included in the deepest layer at the peri-oral region. This study may explain how and why the subtle facial animation is created according to the various muscle morphologies and attachment patterns. It is believed that the arrangement and insertion patterns of the ZMj, as clarified in this study, will provide the critical information for the surgical planning and procedures for recreating the natural personal appearances and preserving the function of the facial expressions.

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국문요약

입꼬리의 근육배열양상 관점에서 큰광대근 닿는곳의 해부학적 연구

연세대학교 대학원 치의학과

심 경 섭

입 주위 얼굴근육 (facial muscle)의 해부학에 기본을 둔 얼굴표정의 정확한 지식은 얼굴부위의 수술과 치과보철학, 교정학 등에서 필수적이며, 매우 중요하다. 또한 이러한 수술은 환자의 요구에 따라 점점 더 발전해 가는 추세이다. 얼굴표정은 기본적으로 여섯 가지 (슬픔, 노여움, 기쁨, 무서움, 싫음, 놀람)로 분류된다. 이러한 얼굴표정의 변화는 얼굴 부위 중 특히 입 주위 표정근육의 수축에 의한 입 모양의 변화에 의해 뚜렷하게 나타난다. 여러 입 주위의 근육 중에서도 큰광대근 (zygomaticus major muscle)은 얼굴표정에 가장 중요한 역할을 한다. 또한 입 주위 개개의 근육들은 세 층으로 나뉘는 얇은 층과 한 층의 깊은 층으로 구분된다. 이 중 큰광대근은 첫째 층과 셋째 층에, 입꼬리올림근 (levator anguli oris)은 가장 깊은 넷째 층에 놓여 있다고 한다. 그리고 대부분의 교과서와 해부학 그림책에도 입꼬리올림근보다 얇은 층에 큰광대근이 놓여 있는 것으로 기술되어 있으나, 몇몇 교과서에는 큰광대근이 입꼬리올림근보다 깊은 층에 놓여 있다고 설명되고 있다. 따라서 이 연구의 목적은 큰광대근의 해부를 통해 큰광대근의 배열과 입 주위에서 큰광대근 닿는곳의 형태변이를 살펴보기 위함이다. 재료로 고정된 한국인 시체 70쪽 (남: 38쪽, 여: 32쪽, 평균나이: 67.4세)을 사용하였다.

큰광대근이 두갈래로 나뉘는 두갈래광대근 (bifid zygomaticus)은 40%에서 관찰되었다. 큰광대근의 닿는곳과 근육배열양상에 따라 4가지 유형으로 분류하였다. 큰광대근의 얇은 부분은 입꼬리올림근의 얇은층에 깊은 부분은 깊은층에 위치하는 I형은 54.3% (38예)로 가장 많았으며, I형과 같이 얇은 부분과 깊은 부분으로 나뉘지만, 얇은 부분이 입꼬리올림근과 같은 층에 위치하는 IV형은 5.7% (4예)로 가장 적었다. 큰광대근이 얇은 부분, 중간 부분, 깊은 부분의 세 부분으로 나뉘어 각각 입꼬리올림근의 얇은층, 같은층, 깊은층에 위치하는 II형은 24.3% (17예)에서 나타났다. 큰광대근이 하나의 섬유로만 구성되어 입꼬리올림근의 깊은층에 위치하는 III형은 15.7% (11예)에서 나타났다. 이와 같이 모든 경우에서 큰광대근의 섬유는 입꼬리올림근보다 깊게 위치하는 부분이 존재하였다.

이 연구에서 밝힌 큰광대근 닿는곳의 양상과 근육배열양상은 입 주위의 얼굴재건수술 등을 실행하고, 계획할 때 유용하게 이용되리라 생각된다.