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Anatomy and Incidence of the Variations of Zygomaticus Minor and Zygomaticus Major Muscles in a Brazilian Sample

Anatomía e Incidencia de las Variaciones de los Músculos Cigomático Menor y Cigomático Mayor en una Muestra Brasileña

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SUMMARY: The muscles of facial expression function primarily to convey facial emotions, but also play roles as sphincters, dilators, and movers of facial structures. The zygomaticus minor and major muscles are essential for expressing emotions, especially smiling, and exhibit significant anatomical variability. The zygomaticus minor originates from the zygomatic bone and inserts into the skin of the upper lip, playing a crucial role in elevating the upper lip. The zygomaticus major originates near the zygomatic arch and inserts into the orbicularis oris muscle, pulling the angle of the mouth laterally. These muscles show variations in their morphology, including differences in the number of muscle bellies, fiber orientation, and attachment sites. Understanding these variations is fundamental for facial aesthetic surgery, botulinum toxin injections, and forensic craniofacial reconstructions. This study aimed to investigate the anatomical variations of the zygomaticus minor and major muscles in a sample of 70 human cadavers, revealing significant variation in muscle origin, belly structure, and insertion. These findings emphasize the importance of recognizing anatomical differences in clinical practices and educational contexts, particularly in procedures involving the middle third.

KEY WORDS: Facial expression; Muscles; Anatomy; Zygoma.

INTRODUCTION

The primary function of the muscles of facial expression is to provide facial expressions, but these muscles also act as sphincters and dilators of the facial orifices, as well as elevators and depressors of facial structures (Hutto & Vattoth, 2015). These muscles are typically very thin. They originate from the bone but insert directly into the skin of the face (Ghassemi *et al*., 2003).

The zygomaticus minor muscle is a superficial muscle of facial expression that originates from the zygomatic bone, close to the zygomaticomaxillary suture. It runs obliquely across the cheek, passing through the muscle fibers of the orbicularis oris, and inserts into the subcutaneous tissue of the upper lip (Hutto & Vattoth, 2015; Kaplan, 2017; Zabojova *et al*., 2018). It is involved in the expression of many different facial emotions and is a crucial muscle for smiling (Choi *et al*., 2014; Kaplan, 2017). It slightly displaces the upper lip outwards and upwards, exposing the upper teeth, as well as laterally (Youn *et al*., 2012; Kaplan, 2017). The zygomaticus minor muscle has also been shown to work in conjunction with the levator labii superioris and levator labii superioris alae nasi muscles (Youn *et al*., 2012).

The zygomaticus major muscle lies anterior to the parotid duct where it enters the fibers of the buccinator muscle (Hutto & Vattoth, 2015). Its origin is located on the zygomatic bone, lateral to the origin of the zygomaticus minor muscle, runs inferomedially on the cheek, and inserts into the orbicularis oris muscle (Hutto & Vattoth, 2015; Kaplan, 2017; Phan & Onggo, 2019). It pulls the angle of the mouth superiorly laterally and plays an important role in facial expression, especially in smiling (Hu *et al*., 2008;

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Kaplan, 2017; Phan & Onggo, 2019). The anatomy of the muscles of facial expression often presents significant morphological variability with respect to their presence, dimensions, shape, insertion patterns and orientation, and these anatomical variations can be observed both between the sides of the face of the same individual and between individuals (Kaplan, 2017; Zabojova *et al*., 2018; Phan & Onggo, 2019). They can overlap and cross several planes (Kaplan, 2017).

The zygomaticus minor muscle, like the zygomaticus major muscle, is responsible for the expression of the smile. It may be present or absent, and, if present, it may present anatomical variations, such as the number of muscle bellies, such as the existence of a bifid belly (Zabojova *et al*., 2018). Sicher & DuBrul (1977) reported that the zygomaticus muscle has a well-developed bundle and a dark red color, even in individuals with weak and pale facial muscles. It describes its origin in the temporal process of the zygomatic bone and directs its flattened fibers anteriorly and downwards to meet the labial commissure, together with the fibers of the levator anguli oris muscle.

Testut (1967) separates the zygomaticus muscle into major and minor; however, he reports that the zygomaticus minor muscle is one of the most variable, often being confused in its path or its entire bundle with the zygomaticus major or levator anguli oris muscles. This same author also reports the variation of the zygomaticus minor muscle originating entirely from the orbicularis oculi muscle, in its palpebral segment. Finally, Testut (1967) exposes the variation in the duplication of this muscle. In addition to the variations in the muscle bundles, there is variation in the arrangement, as Peer *et al*. (2022), reported the presence of muscle bundles oriented horizontally and bundles slightly oriented obliquely. Knowledge of the muscles of facial expression, their location and function, as well as their anatomical variations, are essential for surgical planning and for satisfactory results of aesthetic facial procedures, such as the application of botulinum toxin and plastic surgery techniques (Kaplan, 2017; Phan & Onggo, 2019; Sarilita *et al*., 2021). Forensic craniofacial reconstructions also use an understanding of the muscles of the face, and in the case of the zygomaticus minor and major muscles, this knowledge helps to delimit the frontal and lateral surfaces of the cheek (Sarilita *et al*., 2021). In addition, detailed descriptions of the various variations are of interest for application in plastic surgery and in forensic craniofacial reconstructions.

Knowledge of the anatomical variations of the zygomaticus minor and zygomaticus major muscles is necessary for professionals who perform conservative and surgical treatments in the middle third of the face, as well as in teaching anatomy.

The aim of the study was to describe the anatomy and the incidence of the variations of the zygomaticus minor and zygomaticus major muscles.

MATERIAL AND METHOD

The present research was approved by the Research Ethics Committee of the Piracicaba School of Dentistry – FOP/UNICAMP under protocol CAAE: 73366223.6.0000.5418.

Research Design and Sample

This is a descriptive observational study. Seventy human heads were selected from the Anatomy Laboratory of the Piracicaba Dental School (FOP-UNICAMP), which is part of the Biobank "Bones, Teeth, and Human Cadavers", of FOP-UNICAMP. The heads are from adult cadavers, Brazilian individuals, aged between 18 and 80 years and both sexes (40 male and 30 female). Of the 70 cadavers evaluated, 5 specimens were preserved in formalin and 65 specimens were preserved with glycerin.

The study used cadaveric faces from adult individuals that preserved the anatomical structures in the middle third of the face, particularly the facial expression muscles. Cadaveric faces were excluded if they did not preserve the middle third of the face, or if they presented any pathology involving a foreign body in the middle third of the face that interfered with the anatomy of the facial expression muscles.

Analysis of Morphology of the Zygomaticus Major and Minor Muscles

An anatomical study of the middle third of the face was conducted to identify the anatomy of the facial expression muscles, using 70 cadaveric specimens. After this study, the examiner identified the zygomaticus minor and zygomaticus major muscles (when present). The morphology was evaluated observationally, identifying the possible anatomical variations, which were described and classified according to the number of muscle bellies, fiber orientation, and the origin and insertion sites in the middle third of the face (Fig. 1).

Data Analysis

Descriptive statistics (in %) were performed to determine the incidence of anatomical variations of the studied muscles.

Fig. 1. Lateral view of a face (cadaveric specimen). The delimited area represents the region evaluated for the description and classification of the zygomaticus major and minor muscles.

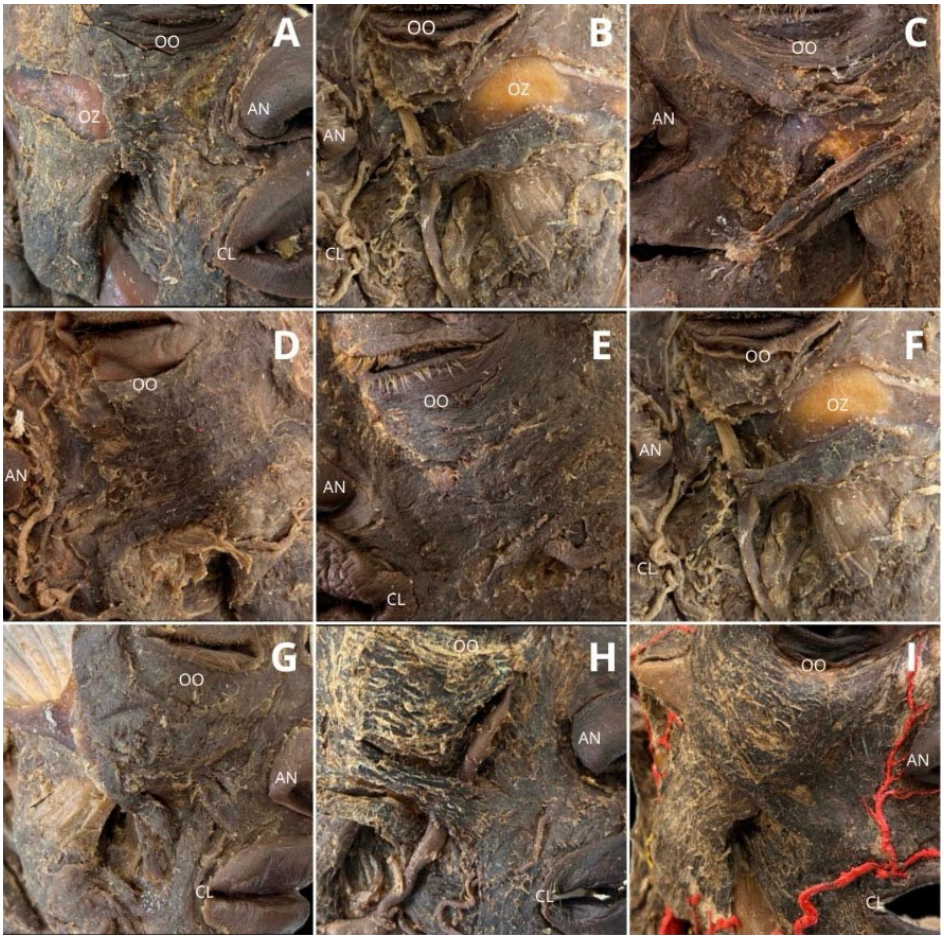

Fig. 2. Lateral view of specimens of each type of muscle found. A. Variation in origin, with the zygomaticus major muscle having its origin more anteriorly. (n=1); B. Variation in origin, with the zygomaticus major muscle having a more lateralized origin. (n=4); C. Double zygomaticus major muscle. (n=1); D. Fusion of the fibers of the zygomaticus major muscle with the orbicularis oculi muscle. (n=3); E. Fusion of the fibers of the zygomaticus major and minor muscles at the origin. (n=2); F. Absence of the zygomaticus minor muscle. (n=7); G. Zygomaticus major muscle with bifurcation of its belly along its path. (n=5); H. Zygomaticus major muscle with fan belly. (n=3); I. Zygomaticus minor muscle with bifurcation of the belly along its path. (n=2).

RESULTS

Of the 70 cadavers evaluated, 64 were hemifaces and 6 were whole heads. Each side of the heads was evaluated individually, resulting in a total of 76 hemifaces evaluated.

Among the hemifaces, 53 (69.7 %) had both the zygomaticus minor and major muscles simultaneously, following the described pattern, with their origin from the body of the zygomatic bone and the lateral surface of this same bone, and insertion into the skin of the upper lip and the angle of the mouth.

Among the zygomaticus major muscles, 58 (76.3 %) showed no variations, while 18 (23.7 %) exhibited some type of variation in origin, muscle belly, or insertion. Among the zygomaticus minor muscles, 59 hemifaces (77.6 %) had the muscle in the described pattern, 7 (9.2 %) were absent, and the remaining 10 (13.2 %) showed some type of variation.

Regarding variations in the zygomaticus major muscle, nine occurred in the origin, eight in the muscle belly, and 14 in the insertion. For the zygomaticus minor muscle, five variations were found in the origin, three in the belly, and five in the insertion.

Variations in muscles' origin

Regarding the origin, the zygomaticus major muscle exhibited 4 types of variations (Fig. 2). The first variation was a bifid origin, which occurred in only one specimen. The second variation was a more anterior origin, observed in only one specimen. The third variation, present in four hemifaces, involved a more lateral origin, even further from the

zygomaticus minor muscle when present. The last variation found was the fusion of the origin fibers of the zygomaticus major muscle and the orbicularis oculi muscle, present in 3 specimens.

There was also one hemiface that showed two zygomaticus major muscles with two separate origins, muscle bellies, and insertions.

Regarding the zygomaticus minor muscle, only one type of variation was found in the origin, in addition to the absence of the muscle in some hemifaces. The variation identified was the fusion of the fibers at the origin with the zygomaticus major muscle, which occurred in two cases.

Variations in belly muscle

In the muscle belly, three variations were identified during the course of the zygomaticus major muscle. The first variation, a bifid muscle belly from the origin, was found in only one hemiface. The second variation, a bifurcation of the muscle belly during its course, was found in four hemifaces. The third variation, described as a fan-shaped muscle belly, was present in three hemifaces.

For the zygomaticus minor muscle, one variation was identified in the muscle belly, described as a bifurcation of the muscle belly along its course, which occurred in three hemifaces.

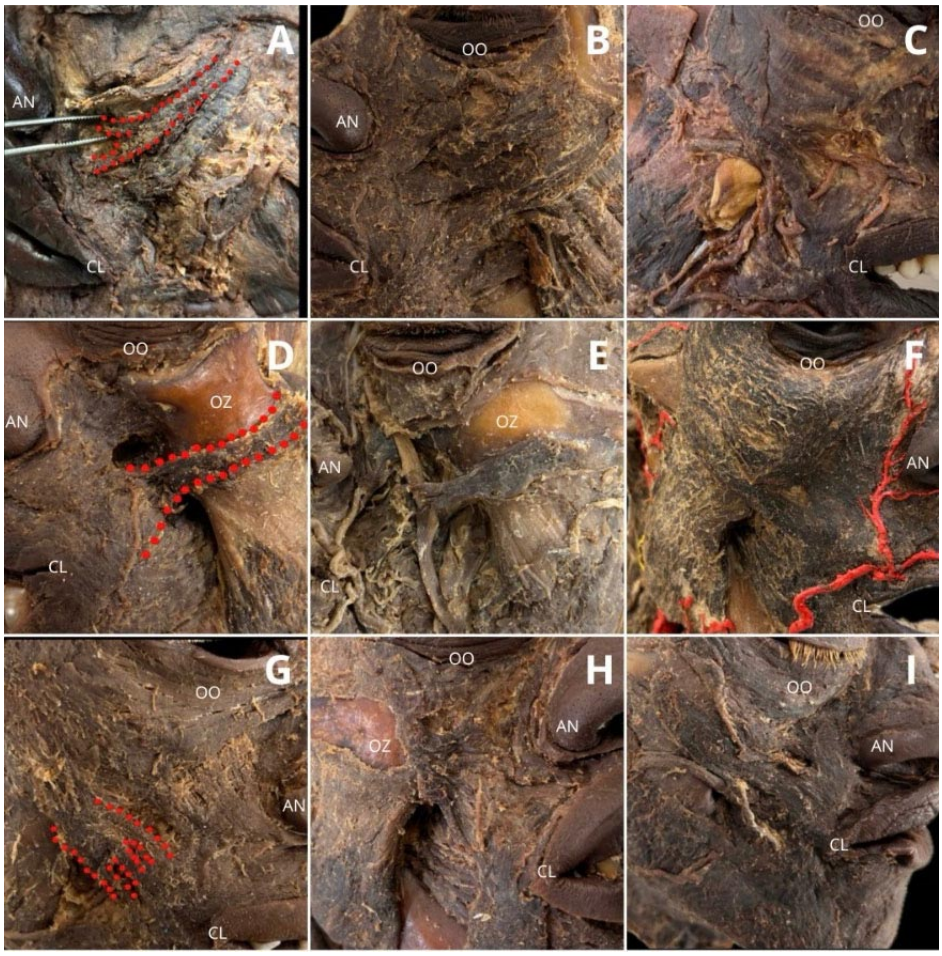

Fig. 3. A. Zygomaticus minor muscle with fibers going to the wing of the nose. (n=1); B. Zygomaticus major Muscle with two insertions, the first at the labial commissure and the second at the lateral part of the upper lip. (n=3); C. Zygomaticus major muscle with two insertions, the first at the corner of the lip and the second at the insertion of the depressor anguli oris muscle. (n=3); D. Zygomaticus major muscle with fan-shaped insertion. (n=3); E. Zygomaticus major muscle inserting into the buccinator muscle. (n=1); F. Zygomaticus major muscle inserting into the lateral part of the upper lip. (n=1); G. Zygomaticus major Muscle with three insertions. (n=2); H. Zygomaticus major Muscle with fibers at the insertion fused with the fibers of the Zygomaticus minor Muscle. (n=1); I. Zygomaticus minor muscle with fused insertion to the levator labii superioris muscle. (n=2).

Variations in muscles' insertion

The insertion was the site that showed the highest number of variations (Fig. 3). Regarding the zygomaticus major muscle, seven variations were identified. The first variation appeared three times and was described as two insertions (Fig. 4), the first at the labial commissure and the second at the lateral part of the upper lip. The second variation was also a double insertion, with the first at the labial commissure and the second at the insertion of the depressor anguli oris muscle, present in 3 muscles. The third variation, described as a fan-shaped insertion, was present in only two hemifaces. Variations 4, 5, and 6 appeared in only one hemiface each. Variation 4 was described as fibers at the insertion fused with the fibers of the zygomaticus minor muscle; variation 5 was insertion into the buccinator muscle; and variation 6 was insertion at the upper and lateral part of the upper lip. The seventh variation identified was the presence of three insertions, which appeared in two hemifaces.

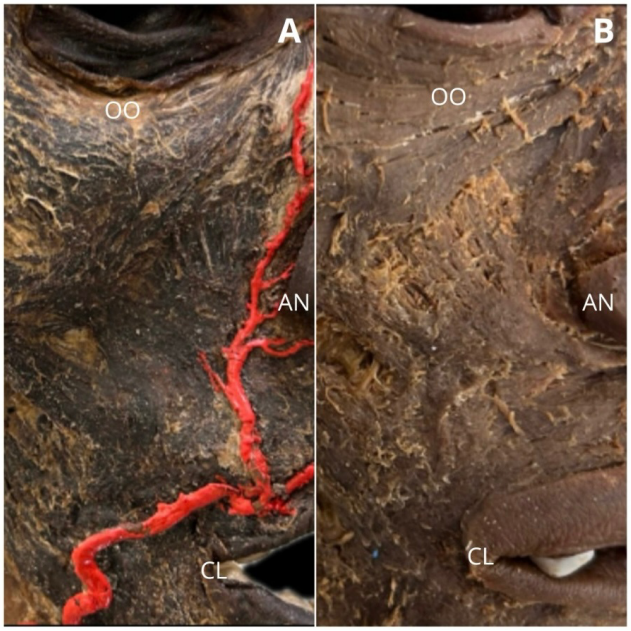

Fig. 4. A. Zygomaticus minor muscle with two insertions, the first with the levator labii superioris muscle and the second with the fibers of the zygomaticus major muscle. (n=2); B. Zygomaticus minor muscle with two insertions going to the upper lip. (n=1).

Regarding the zygomaticus minor muscle, the first variation described appeared in two hemifaces, with the insertion located near the levator labii superioris muscle. The second variation was the presence of two insertions: the first along with the levator labii superioris muscle and the second with the fibers of the zygomaticus major muscle at the lateral part of the lip, which appeared in two hemifaces. One hemiface showed the insertion of the zygomaticus minor muscle both at the alar base of the nose and at the upper lip, described in just one muscle. The last variation described, besides the absence of the muscle, was also a double insertion, but both insertions were directed toward the upper part of the upper lip.

DISCUSSION

The anatomical characteristics of the facial expression muscles are important due to the use of different flaps for the repair of facial tissue loss and facial rejuvenation surgeries (Rubin, 1974). Additionally, knowledge of anatomical variations is essential to avoid errors and provide the patient with appropriate clinical management during the specific procedures for each case (Ferreira *et al*., 2021). The area of the middle third of the face is a challenging region for plastic surgeons and may differ across various ethnicities (Farahvash *et al*., 2010).

In the population evaluated in the present study, variations in origin, muscle belly, and insertion were observed. Variations in the zygomaticus major muscles have been previously reported in the literature. Phan & Onggo (2019) and Pessa *et al*. (1998) suggest that the bifid zygomaticus major muscle clinically presents as a dimple in the cheek. The authors also noted that this is considered a congenital defect (Phan & Onggo, 2019). It is important to note that the anatomical variations of the facial expression muscles can cause changes in an individual's facial expression. In the present study, with respect to the muscle belly of the zygomaticus major, three types of variations were found. Regarding the zygomaticus minor muscle, one variation in the belly was found, and the absence of this muscle was noted in 9.2 % of the hemifaces.

Farahvash *et al*. (2010) conducted a study with the aim of determining the patterns of middle third facial muscles in Persian individuals, and the authors found that the incidence of the bifid zygomaticus major muscle was 19.2 %. Pessa *et al*. (1998) investigated a series of 50 hemifacial dissections in cadavers and found that the incidence of the double zygomaticus major muscle was 34 %. Hu *et al*. (2008) observed 70 hemiface dissections (59 cases of Koreans and 11 cases of French individuals) and reported that the bifid zygomaticus major muscle was observed in 40 % of the cases. Phan & Onggo (2019), performed a meta-analysis to determine the prevalence of the bifid zygomaticus major muscle in different populations. The authors found that this anatomical variation was most prominent in the American subgroup (34 %), followed by the Asian subgroup (27.4 %) and the European subgroup (12.3 %). The overall prevalence of the bifid zygomaticus major muscle was 22.7 % (Phan & Onggo, 2019). However, no previous studies in the literature reviewed reported the prevalence of the bifid zygomaticus major muscle in the Brazilian population.

In the present study, variations in the muscle belly of the zygomaticus major were identified, with three variations observed. The first variation, a bifid belly from the origin, was found in only one hemiface (1.31 %). The second variation, a bifurcation of the belly during its course, was found in 5.26 % of the cases. The third variation was described as a fan-shaped muscle belly, present in 3.94 % of the hemifaces. Again, hemiface 15 on the left showed the double zygomaticus major muscle.

The facial expression muscles are responsible for expressing people's emotions (Phan & Onggo, 2019). Both zygomatic muscles, the major and minor, are responsible for expressing emotions of joy through smiling and laughter (Choi *et al*., 2014; Kaplan, 2017; Phan & Onggo, 2019). According to Dimberg *et al*. (2002) during social interaction, emotional excitement and spontaneous facial mimicry are reflected by an increase in the activity of the zygomaticus major muscle when observing happy facial expressions.

CONCLUSION

In conclusion, the zygomaticus major and zygomaticus minor muscles have variations in origin, muscle belly, and insertion. The facial expression muscles directly influence individual appearance and contribute to emotional expression. Therefore, it is necessary to consider the anatomy of possible individual variations of the facial expression muscles, and their incidence is essential when performing surgical and/or aesthetic procedures on the face.

Conflict of interest. The authors declare that they have no conflict of interest.

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RESUMEN: Los músculos de la expresión facial funcionan principalmente para transmitir emociones faciales, pero también actúan como esfínteres, dilatadores y motores de las estructuras faciales. Los músculos cigomático menor y mayor son esenciales para expresar emociones, especialmente la sonrisa, y presentan una variabilidad anatómica significativa. El músculo cigomático menor se origina en el hueso cigomático y se inserta en la piel del labio superior, desempeñando un papel crucial en la elevación del labio superior. El músculo cigomático mayor se origina cerca del arco cigomático y se inserta en el músculo orbicular de los labios, desplazando lateralmente la comisura labial. Estos músculos presentan variaciones morfológicas, incluyendo diferencias en el número de vientres musculares, la orientación de las fibras y los puntos de inserción. Comprender estas variaciones es fundamental para la cirugía estética facial, las inyecciones de toxina botulínica y las reconstrucciones craneofaciales forenses. Este estudio tuvo como objetivo investigar las variaciones anatómicas de los músculos cigomático menor y mayor en una muestra de 70 cadáveres humanos, revelando una variación significativa en el origen, la estructura del vientre y la inserción muscular. Estos hallazgos resaltan la importancia de reconocer las diferencias anatómicas en la práctica clínica y en contextos educativos, especialmente en procedimientos que involucran el tercio medio.

PALABRAS CLAVE: Expresión facial; Músculos; Anatomía; hueso cigomático.

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