Surgical and Radiologic Anatomy (2024) 46:27–32
https://doi.org/10.1007/s00276-023-03271-z

ORIGINAL ARTICLE

Positional relationships of the origin and course of zygomaticus major with the nasal ala, tragus, philtrum, and lateral canthus for aesthetic treatments and surgeries

Hyun Jin Park[1] · Jin Seo Park[2] · Joe Iwanaga[3,4,5,6,7,8] · R. Shane Tubbs[4,5,8,9,10,11,12] · Mi-Sun Hur[1]

Received: 12 September 2023 / Accepted: 17 November 2023 / Published online: 13 December 2023

Abstract

Purpose The aim of this study was to characterize the origin and course of the zygomaticus major muscle (Zmj) with its topographic relationships with the nasal ala, tragus, philtrum, and lateral canthus.

Methods The Zmj was examined in 50 specimens of 25 embalmed adult Korean cadavers. Facial muscles were dissected to expose the origin and course of the Zmj in 48 specimens of 24 cadavers. The 25th cadaver was sectioned to obtain images of the Zmj.

Results The positional relationships of the Zmj origin with the nasal ala and the tragus were classified into three categories. A horizontal line through the center of the Zmj origin and the nasal ala passed through the tragus in 20 of 48 specimens (41.7%), the intertragic notch in 18 specimens (37.5%), and above the tragus in 10 specimens (20.8%). In a horizontal section of the head, the Zmj origin was located near the level of the nasal ala and tragus. In a coronal section of the head, the fibers of the Zmj arising at its origin were located close to the zygomatic bone, lateral to the zygomaticus minor muscle.

Conclusion By combining dissection with the analysis of sectioned images and ultrasound images of the Zmj, this study has yielded positional information for easily predicting the location of the origin and the course of the Zmj and its related structures underlying the skin.

Keywords Lateral canthus · Nasal ala · Tragus · Philtrum · Zygomaticus major

✉ Mi-Sun Hur
mshur@cu.ac.kr

[1] Department of Anatomy, Daegu Catholic University School of Medicine, Daegu, Korea

[2] Department of Anatomy, Dongguk University School of Medicine, Gyeongju, Korea

[3] Department of Oral and Maxillofacial Anatomy, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan

[4] Department of Neurosurgery, Tulane Center for Clinical Neurosciences, Tulane University School of Medicine, New Orleans, LA, USA

[5] Department of Neurology, Tulane Center for Clinical Neurosciences, Tulane University School of Medicine, New Orleans, LA, USA

[6] Dental and Oral Medical Center, Kurume University School of Medicine, Kurume, Fukuoka, Japan

[7] Division of Gross and Clinical Anatomy, Department of Anatomy, Kurume University School of Medicine, Kurume, Fukuoka, Japan

[8] Department of Structural & Cellular Biology, Tulane University School of Medicine, New Orleans, LA, USA

[9] Department of Anatomical Sciences, St. George's University, St. George's, West Indies, Grenada

[10] Department of Surgery, Tulane University School of Medicine, New Orleans, LA, USA

[11] Department of Neurosurgery and Ochsner Neuroscience Institute, Ochsner Health System, New Orleans, LA, USA

[12] University of Queensland, Brisbane, Australia

Introduction

Aesthetic facial treatments require knowledge of the target structures underlying the facial skin. The location of the zygomaticus major muscle (Zmj) is important for achieving safer and more effective treatments and avoiding unexpected contraindications especially when performing SMAS (superficial musculoaponeurotic system) lifting and botulinum neurotoxin type A (BoNT-A) injection for lower crow's feet or accordion wrinkle. The Zmj has also been targeted using ultrasound-guided BoNT-A injections to treat asymmetrical smile and in ultrasound-guided needle EMG to identify Zmj paralysis in patients with facial asymmetry [7, 12].

Previous studies have revealed the positional relationships of the Zmj relative to anatomical landmarks and the facial muscles. Mendelson [8] found obliquely oriented fibers of the Zmj at 5.5 cm anterior to the tragus. Mowlavi and Wilhelmi [9] observed the lateral border of the Zmj at 4.4 ± 2.2 mm (mean ± SD) lateral and parallel to the oblique line extending from the mental protuberance to the notch defined at the most anterior/inferior aspect of the temporal fossa at the junction of the frontal process and temporal process of the zygomatic bone. Hur et al. [3] revealed the general pattern and variations in heights and spatial relationships of the Zmj with the facial muscles passing beneath the nasolabial fold. Mowlavi and Wilhelmi [9] stated that the location of the lateral border of the Zmj may reduce the probability of nerve injury, because the nerves innervating the Zmj may penetrate the deep SMAS layer more laterally and be prone to injury following release of the SMAS in transition from the subSMAS to the supramuscle (prezygomaticus major) plane. Using facial landmarks such as the nasal ala, tragus, philtrum, and lateral canthus will make it easier to identify the location of the Zmj.

The aim of this study was to characterize the origin and course of the Zmj with its topographic relationships with the nasal ala, tragus, philtrum, and lateral canthus. This information will be useful for determining the location of the Zmj underlying the facial skin using facial landmarks when performing various treatments and surgeries for aesthetics.

Materials and methods

Specimens and dissection of cadavers

The Zmj was examined in 50 specimens of 25 embalmed adult Korean cadavers (13 males and 12 females) with a mean age of 73.4 years (age range 40–95 years). Facial muscles were dissected to expose the origin and course of the Zmj in 48 specimens of 24 cadavers. The 25th cadaver was sectioned to obtain images of the Zmj. There was no history of trauma or surgery in the midface. The study was performed in accordance with the Declaration of Helsinki arising from the 64th WMA General Assembly in Fortaleza, Brazil in October 2013.

Positional relationships of the origin and course of the Zmj

In 48 specimens of 24 cadavers, the positional relationships of the origin and course of the Zmj were observed based on a circle and lines defined as follows (referring to Fig. 1):

1. The circle indicates where the Zmj origin is located.
2. H1 is the horizontal line passing through the nasal ala.
3. H2 is the horizontal line passing through the middle of the philtrum.
4. P is the perpendicular line passing through the lateral canthus.

Sectioned images of the origin of the Zmj

We used sectioned images of the head of one cadaver obtained from the Visible Korean Project. The high spatial resolution of the head sectioned images (obtained at intervals of 0.2 mm with a pixel size of 0.06 mm × 0.06 mm) and the use of true color (48 bits) [6] meant that face structures including the Zmj with facial landmarks (nasal ala and tragus) could be identified accurately in the images of horizontal and coronal planes.

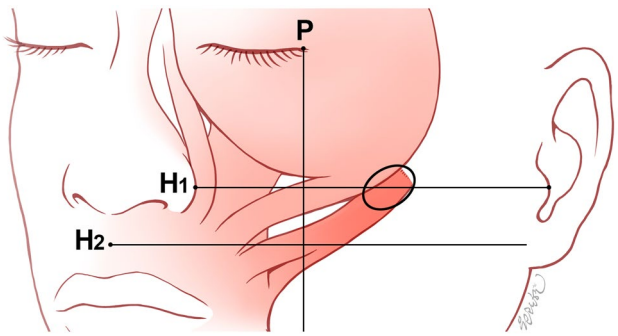

Fig. 1 Facial landmarks for defining positional relationship of the origin and course of the Zmj on the face surface. The circle indicates where the Zmj origin is located. H1 is the horizontal line passing through the nasal ala. H2 is the horizontal line passing through the middle of the philtrum. P is the perpendicular line passing through the lateral canthus

Results

Location of the Zmj origin on the face surface

The Zmj origin was located horizontally on H1 and vertically between P and the tragus in all 48 of the investigated specimens (100%). The positional relationships of the Zmj origin with the nasal ala and the tragus were classified into three categories (Fig. 2). A horizontal line through the center of the Zmj origin and the nasal ala passed through the tragus in 20 of 48 specimens (41.7%), the intertragic notch in 18 specimens (37.5%), and above the tragus in 10 specimens (20.8%). The perpendicular level of the Zmj origin was located lateral to that of the eyebrow in all specimens (100%).

The positional relationships of the Zmj with the philtrum and lateral canthus were also classified into three categories (Fig. 3). The location where H2 crossed P was where the lower third of the Zmj was located in 38 specimens (79.2%)

Fig. 2 Positional relationships of the Zmj origin with the nasal ala and tragus. A horizontal line through the Zmj origin and nasal ala passed through the tragus **A**, the intertragic notch **B**, or above the tragus **C**. The white dots indicate the tragus. OOc, orbicularis oculi muscle; LLS, levator labii superioris. The horizontal line passes through the center of the Zmj origin

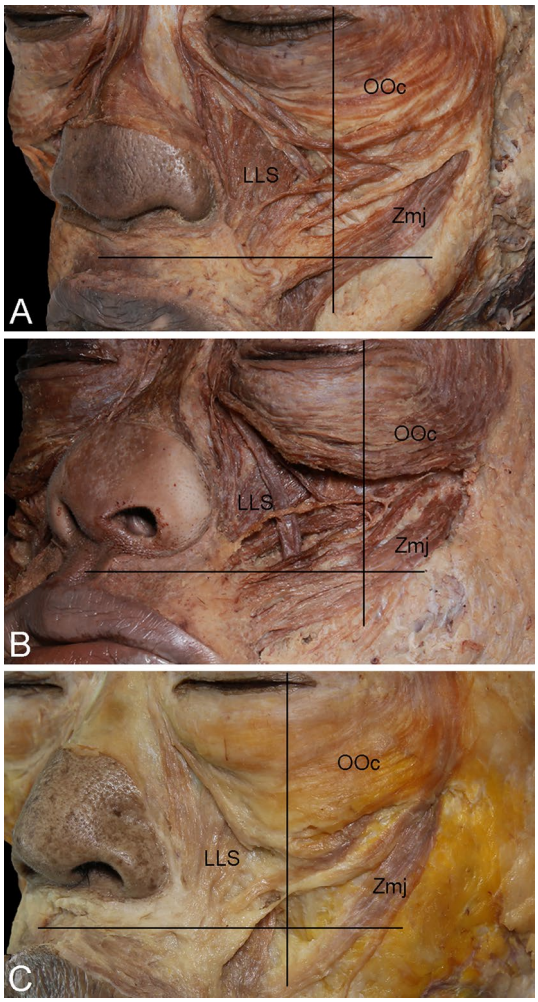

Fig. 3 Positional relationships of the Zmj with the philtrum and lateral canthus. The location where H2 (horizontal line) crossed P (perpendicular line) was typically where the lower third of the Zmj was located **A** and the middle part of the Zmj was located **B**. **C** The lower third of the Zmj was typically located below that position

and the middle part of the Zmj was located in 1 specimen (2.1%). The lower third of the Zmj was located below that location in nine specimens (18.8%). Along the entire course of the Zmj, the fibers arising at its origin were thicker than other Zmj fibers.

Sectioned images of the head for observing the fibers of the Zmj arising at its origin

The position of the Zmj origin relative to facial landmarks including the nasal ala and tragus was revealed in sectioned images of the head (Fig. 4). In a horizontal section of the head, the Zmj origin was located near the level of the nasal ala and tragus. In a coronal section of the head, the fibers of the Zmj arising at its origin were located close to the zygomatic bone, lateral to the zygomaticus minor muscle.

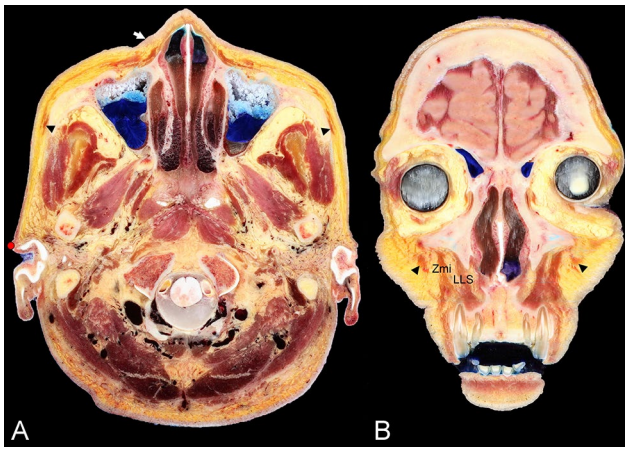

Fig. 4 Sectional images of the head for observing the fibers of the Zmj (black arrowheads) arising at its origin. **A** In a horizontal section of the head, the fibers of the Zmj arising at its origin were located near the level of the nasal ala (white arrow) and tragus. **B** In a coronal section of the head, the arising fibers of the Zmj were located close to the zygomatic bone, posterolateral to zygomaticus minor (Zmi) and LLS. The red dot indicates the tragus

Ultrasound images for observing the fibers of the Zmj arising at its origin

Along H1, the fibers of the Zmj arising at its origin on the zygomatic bone were observed as a distinct oval shape in longitudinal and transverse views. Zmj fibers were observed on the maxilla at the horizontal level where the middle of the philtrum crossed P (Fig. 5).

Discussion

This study developed a method for easier identification of the origin and course of the Zmj on the face surface using several landmarks, dissection, sectioned images, and ultrasound images. In general, a horizontal line through the Zmj origin and the nasal ala passed through the tragus or the intertragic notch. In most specimens, the lower third of the Zmj was located at the intersection of H2 and P. The Zmj origin was located at the perpendicular level between the lateral canthus and the tragus. Knowledge of the positional relationships of the Zmj with the landmarks on the face surface can be helpful for predicting the location of the Zmj origin and its course underlying the facial skin when targeting this muscle for aesthetic treatments. In addition, MRI, CT, and ultrasound images can be used to easily distinguish the Zmj and its adjacent structures at the levels of the nasal ala and tragus.

The present study found that the origin of the Zmj was located on H1 in all specimens. Hur et al. [2] reported that the inferior length of the OOc at the lateral canthus level

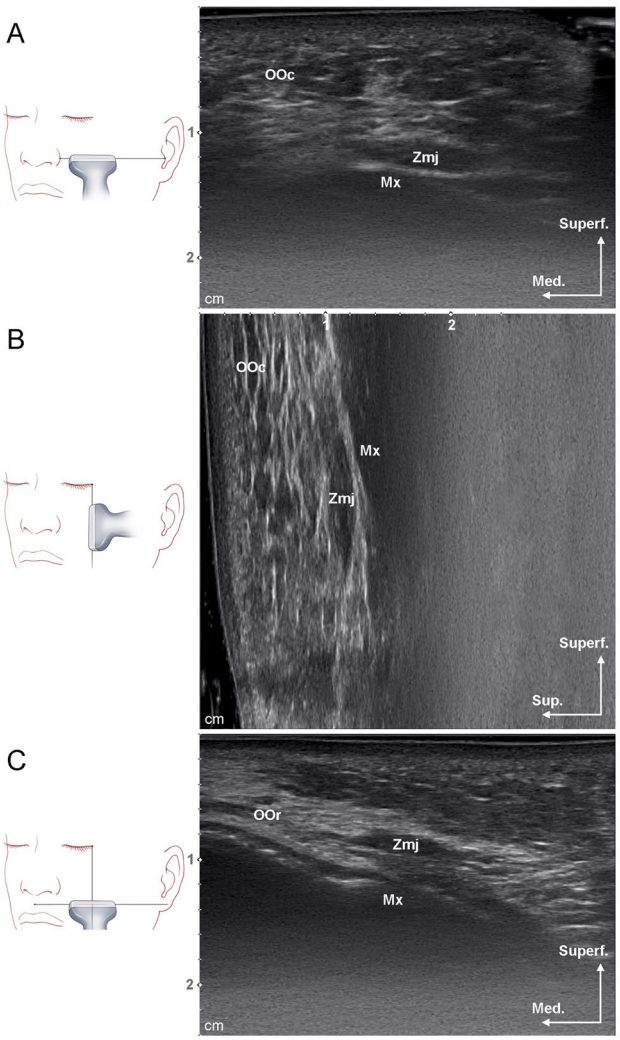

Fig. 5 Ultrasound images of the Zmj. At the horizontal level of the nasal ala, the fibers of the Zmj arising at its origin observed in transverse **A** and longitudinal **B** views. **C** Zmj fibers in the transverse view were found on the maxilla (Mx) where H2 crossed P. Superf, superficial; Med, medial

was 30.5 ± 3.7 mm. Those authors also stated that for the maximum inferior length of the OOc, the inferior margin of the OOc at the lateral canthus was located just above the nasal base, whereas for the minimum inferior length of the OOc, the inferior margin of the OOc at the lateral canthus was located just above the nasal ala. It can, therefore, be concluded that the inferior margin of the OOc usually extends just above the level of the nasal ala, whereas the Zmj origin is located at the level of the nasal ala.

Caution is needed when targeting the Zmj in BoNT-A injections due to the possibility of adverse situations when its location is predicted incorrectly. Injecting BoNT-A into the mouth-corner elevators such as the Zmj may result in an awkward and asymmetrical smile [6]. The mouth corner will not be elevated when attempting to smile if the Zmj is

paralyzed, and so, great care is needed to avoid both deep injections into the Zmj and large doses of BoNT-A even during superficial injections [10]. Furthermore, a selective approach to the Zmj can be attempted when using BoNT-A to treat the nasolabial fold in cases where smiling exaggerates the nasolabial fold or induces asymmetry. The "Zmj-type" nasolabial fold caused by excessive contraction of the Zmj results in elongation of this structure up to the lateral cheek [10].

The vector of SMAS lifting in rhytidectomy is often described in relation to the Zmj, so that the suspension of SMAS prevents distortion of the mimetic musculature and an appearance where it is obvious that a facelift has been performed. The native vector of the Zmj varies significantly between rhytidectomy patients [5]. Wang et al. [14] stated that in most facelift surgeries, the SMAS should be mainly be manipulated parallel to the direction of the Zmj, implying the importance of knowledge of the Zmj location.

The SMAS has been shown to attach to the lateral border of the Zmj, with the superficial and deep SMAS layers surrounding that muscle. Therefore, traction on the SMAS posteriorly only deepens the nasolabial fold due to its attachment to the underlying muscles including the Zmj [1, 11]. In addition, extended subSMAS dissection requires release of the SMAS typically from the upper lateral border of the Zmj and continued dissection medial to this muscle [9]. Therefore, knowledge of the positional relationships of the Zmj origin and course on the face surface relative to landmarks such as the nasal ala, tragus, philtrum, and lateral canthus will allow clinicians to predict the location and vector of the Zmj before performing SMAS lifting.

Limitation of this study is a relatively small sample size. Thus, to make up for such limitation we demonstrated using several approaches, such as utilizing dissection, sectioned images, and ultrasound images of the Zmj, providing classification of the positional relationships of the Zmj origin with the nasal ala and the tragus.

Conclusion

By combining dissection with the analysis of sectioned images and ultrasound images of the Zmj, this study has yielded positional information for easily predicting the location of the origin and the course of the Zmj and its related structures underlying the skin. This information is crucial when performing aesthetic treatments such as BoNT-A injections and SMAS lifting, or when evaluating MRI, CT, and ultrasound images.

Acknowledgements The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially increase mankind's overall knowledge, which can then improve patient care. Therefore, these donors and their families deserve our highest gratitude [4].

Author contributions HJP and MSH: project development, data collection, data analysis, manuscript writing, and manuscript editing; JSP: manuscript writing, manuscript editing; JI: manuscript writing and manuscript editing; RST: manuscript writing and manuscript editing; All authors have read and agreed to the published version of the manuscript.

Funding This work was supported by a National Research Foundation of Korea (NRF) Grant funded by the Korean government (MSIT) (No.2020R1C1C1003237). This study was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2021R1F1A1063044).

Data availability The data that support the fndings of this study are available from the corresponding author, Mi-Sun Hur, upon reasonable request.

Declarations

Conflict of interest The authors have declared that no competing interests exist.

References

1. Barton FE Jr (1992) The SMAS and the nasolabial fold. Plast Reconstr Surg 89:1054–1057 (**discussion 1058-1059**)
2. Hur MS, Iwanaga J, Tubbs RS, Moon YS, Kim H (2023) Width of the orbicularis oculi fibers extending to the upper lip with the lateral and inferior lengths of the orbicularis oculi at the lateral canthus level: application to botulinum neurotoxin type A injection for crow's feet. Surg Radiol Anat 45:461–468. https://doi.org/10.1007/s00276-023-03103-0
3. Hur MS, Jehoon O, Yang HM, Kwon HJ, Lee S, Lim HS, Lim SY, Oh CS (2020) Heights and spatial relationships of the facial muscles acting on the nasolabial fold by dissection and three-dimensional microcomputed tomography. PLoS One 15:e0237043. https://doi.org/10.1371/journal.pone.0237043
4. Iwanaga J, Singh V, Ohtsuka A, Hwang Y, Kim HJ, Moryś J et al (2021) Acknowledging the use of human cadaveric tissues in research papers: recommendations from anatomical journal editors. Clin Anat 34:2–4. https://doi.org/10.1002/ca.23671
5. Jacono AA, Bryant LM, Alemi AS (2020) Optimal facelift vector and its relation to zygomaticus major orientation. Aesthet Surg J 40:351–356. https://doi.org/10.1093/asj/sjz114
6. Kim HJ, Seo KK, Lee HK, Kim J (2016) Clinical anatomy of the face for filler and botulinum toxin injection. Springer, Singapore
7. Lee HJ, Kim JS, Youn KH, Lee J, Kim HJ (2018) Ultrasound-guided botulinum neurotoxin type A injection for correcting asymmetrical smiles. Aesthet Surg J 38:130–134. https://doi.org/10.1093/asj/sjy128
8. Mendelson BC (1992) Correction of the nasolabial fold: extended SMAS dissection with periosteal fixation. Plast Reconstr Surg 89:822–833 (**discussion 834-835**)
9. Mowlavi A, Wilhelmi BJ (2004) The extended SMAS facelift: identifying the lateral zygomaticus major muscle border using bony anatomic landmarks. Ann Plast Surg 52:353–357. https://doi.org/10.1097/01.sap.0000099712.80882.6b
10. Seo KK (2017) Botulinum Toxin for Asians. Springer, Singapore

11. Teimourian B, Delia S, Wahrman A (1994) The multiplane face lift. Plast Reconstr Surg 93:78–85. https://doi.org/10.1097/00006534-199401000-00011
12. Yoo SH, Kwon HK, Lee SH, Lee SJ, Ha KW, Yun HS (2013) Diagnosis of zygomaticus muscle paralysis using needle electromyography with ultrasonography. Ann Rehabil Med 37:433–437. https://doi.org/10.5535/arm.2013.37.3.433
13. You Y, Kim CY, Kim SK, Chung BS, Har D, Choi J, Park JS (2022) Advanced-sectioned images obtained by microsectioning of the entire male body. Clin Anat 35:79–86. https://doi.org/10.1002/ca.23795
14. Wang CH, Liu HJ, Tsai YT, Lin HI, Wu PY, Lin JW (2019) An innovative thread-looping method for facial rejuvenation: minimal access multiple plane suspension. Plast Reconstr Surg Glob Open 7:e2045. https://doi.org/10.1097/GOX.0000000000002045