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Topographic and anatomical aspects of the development of the technique of conductive anesthesia of the zygomaticofacial and zygomaticotemporal nerves

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Abstract
Introduction and objective: The branching of the trigeminal nerve on the face has an individual anatomical variability. The individual variability of innervation of soft tissues of the maxillofacial area should be taken into account during their local anesthesia.
The purpose of the study: to develop a methods of conductive anesthesia of the zygomaticofacial and zygomaticotemporal nerves, taking individual topographic and anatomical features of their branching.
Materials and methods: Craniometric studies were performed on 32 natural skulls of corpses of various ages and 60 images of head section of patients were done in a 3D reconstruction by multi-detector row spiral computer tomographer. The cranial index was determined, counting the number of zygomaticofacial and zygomaticotemporal foramina on each skull and taking onto account the peculiarities of their location.
Results: It was discovered that there is a certain feature of the localization of the zygomaticofacial and zygomaticotemporal foramina on the lateral (facial) and temporal surfaces of the zygomatic bone, depending on the type of structure of the skull. Taking into account the results of craniometric studies as well as the individual topographic and anatomical features of zygomaticofacial and zygomaticotemporal nerves branching in people with different types of skull structure, the techniques of conduction anesthesia of the branches of the zygomaticofacial and zygomaticotemporal nerves was developed. In order to anesthetize this nerve in people with broad and oblong face shape, anatomical variability of its branching should be considered.
Conclusions: The location and amount of zygomaticofacial and zygomaticotemporal foramina vary depending on the shape of the skulls. It was found that the most distinguished among the amount and location of these holes are dolichocephalic and brachiocephalic skulls. In the development of methods of conducting anesthesia of zygomaticofacial and zygomaticotemporal nerves, individual anatomical features of their branching in the zygomatic and temporal areas were taken into account.

Keywords: Zygomaticofacial and zygomaticotemporal nerves, craniometric studies, conductive anesthesia, skull shape

Introduction
It is well known that the sensory innervation of the maxillofacial area (MFA) is quite complicated. In the soft tissues of the face the sensory branches of the trigeminal nerve, as well as the cervical superficial nerve plexus are branching (Fig.1) [1, 2]. In adjacent anatomical sites these nerves are anastomosed with each other. The branching of the trigeminal nerve on the face has an individual anatomical variability dividing into two types [3].

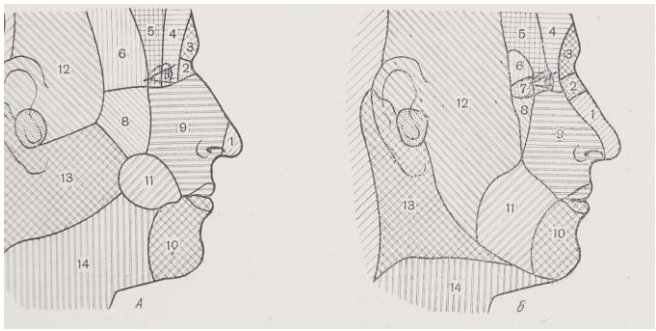

Fig 1: Types of branching on the face of the superficial branches of the trigeminal nerve and cervical nerve plexus (according to V.N. Shevkunenko)

A – with dominating of the superficial branches of the maxillary nerve
and cervical nerve plexus on the face. B – with dominating on the face of the superficial branches of the mandibular nerve
1 – external nasal branch of anterior ethmoidal nerve, 2 – infratrochlear nerve, 3 – supratrochlear nerve, 4 – frontal nerve, 5 – supraorbital nerve, 6 – zygomaticotemporal nerve, 7 – palpebral branches of lacrimal nerve, 8 –zygomaticofacial nerve, 9 – infraorbital nerve, 10 – mental nerve, 11 – long buccal nerve, 12 – auriculotemporal nerve, 13 – great auricular nerve, 14 – transverse cervical nerve

In the first type the innervation of the face is dominated by the superficial branches of the maxillary nerve, its branches (zygomaticotemporal, zygomaticofacial and infraorbital nerves) are involved in sensitive innervation of the temporal and cheek areas. The second type on the face is dominated by superficial sensory branches of the mandibular nerve, its branches (buccal and mental nerves) are involved in sensitive innervation of the cheek area [3]. Here, buccal nerve forms a plexus with the facial nerve, infraorbital nerve and mental nerve [4-7]. The individual variability of innervation of soft tissues of the maxillofacial area should be taken into account during their local anesthesia.
In order to anesthetize the upper part of the cheek and soft tissues of the zygomatic area, besides the conductive anesthesia of the buccal nerve, we performed a blockade of the zygomaticofacial nerve in accordance with a technique, when the anesthetic is injected at the lower outer edge of the orbit [8-10], where the zygomaticofacial foramina are located, through which the branches of the zygomaticofacial nerve go outside from the zygomatic bone [11]. However, the buccal and zygomatic areas were completely anesthetized in 74% of cases. In 26% of cases with uncomplete anesthesia of buccal and zygomatic areas revealed clinically we noticed that only the central part of the zygomatic region as well as the small area adjoining to the lower outer edge of the orbit were anesthetized. The upper part of the zygomatic region adjoining to the zygomaticofrontal suture as well as the lateral part adjoining to the zygomaticotemporal suture remained sensitive. When zygomaticotemporal nerves were blocked according to the known method (near the zygomaticofrontal suture, where the zygomaticotemporal nerve go outside from the zygomatic bone) [8]
In 31% of cases, we were not able to completely anaesthetize the anterior part of the temporal area. The absence of the necessary anesthetic effect in these cases was associated, in our opinion, with the individual anatomical variability of the branching of the zygomaticofacial and zygomaticotemporal nerves on the face. These patients were broad-faced or long-faced.
The purpose of the study: to develop a methods of conductive anesthesia of the zygomaticofacial and zygomaticotemporal nerves, taking individual topographic and anatomical features of their branching.

Materials and Method: Craniometric studies were performed on 32 natural skulls of corpses of various ages and 60 images of head section of patients were done in a 3D reconstruction by multi-detector row spiral computer tomographer “Aquilion” (“Toshiba Medical Systems”, Japan). The cranial index represents the correlation between the transverse diameter (width) of the face and the longitudinal (length) in percentage. If the index is more than 80,9%, then this form of the skull should be attributed to brachycephalic (short-headed), if it is within 76-80,9%, then – to the mesocephalic (medium-headed). The shape of the skull, in which this figure was 75,9% or less, belonged to the dolichocephalic (long head). The cranial index was determined, counting the number of zygomaticofacial and zygomaticotemporal foramina on each skull and taking onto account the peculiarities of their location. The position of these openings was measured in relation to the fixed anatomical landmarks: zygomaticofrontal suture, zygomaticotemporal suture, lower outer edge of the orbit.
The probability of the obtained results was evaluated according to the Student probability criterion by statistically computing the data using common methods of statistics from the package “Statistica-7”. A ‘P’ value of 0,05 was considered for statistical significance.

Results: We have found anatomical variability of the structure of the skull and the variability of the amount of zygomaticofacial foramina. The dolichocephalic skull was determined in 34 cases, mesochephalic type – in 40 cases, brachycephalic type – in 18 cases (Table 1).
There is a certain feature of the localization of the zygomaticofacial foramina on the lateral (facial) surface of the zygomatic bone, depending on the type of structure of the skull.

Table 1: Anatomical variability of the number of zygomaticofacial foramina depending on the types of skull structure

Type of skull structure (total number of cases)	Detected number of zygomaticofacial foramen on the analyzed skulls (number of studied skulls,% of cases *)			
	1 foramen	2 foramina	3 foramina	4 foramina
Dolichocephalic type (34)	10 (29,4%)	12 (35,3%)	9 (26,4%)	3 (8,8%)
Mesochephalic type (40)	23 (57,5%)	11 (27,5%)	4 (10,0%)	2 (5,0%)
Brachycephalic type (18)	7 (38,9%)	6 (33,3%)	5 (27,8%)	Not detected

Note: * - The percentage of cases in each group was counted according to the total number of skulls that had the same type of structure.

In people with mesocephalic skulls foramina in most cases are located by "chain", congruent to the lower-outer edge of the orbit, away from this anatomical formation at 8.2 ± 2.3 mm (Fig. 2).

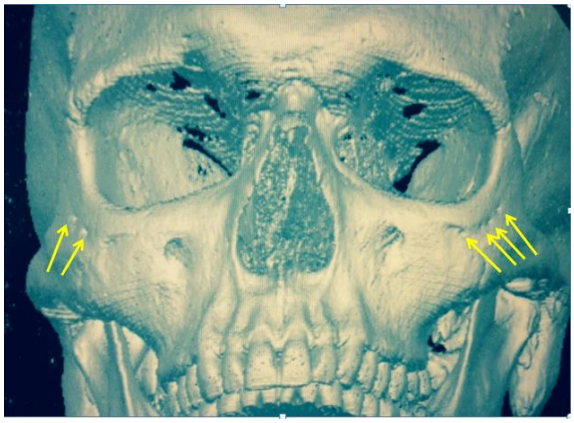

Fig 2: Computer tomography of the facial skull in 3D reconstruction. Craniometric study. Mesocephal structure of the skull. There are four zygomaticofacial foramina on the facial surface of the zygomatic bone on the left and two zygomaticofacial foramina on the right (shown with arrows)

In dolichocephalic skulls zygomaticofacial foramina are grouped not only in the area adjacent to the lower-outer edge of the orbit. In 35.2% of cases, they took place at different distances between each other and were close to the zygomaticofrontal suture at 6.9 ± 2.3 mm (Fig. 3).

In the brachycephalic skulls most of the zygomaticofacial foramina are centered near the lower-outer edge of the orbit. They were located at a distance of 9.3 ± 2.7 mm to zygomaticofrontal suture. However, in 33.3% of cases, they were shifted from the orbit to the zygomaticotemporal suture and were located at a distance of 14.2 ± 2.3 mm to it (Fig. 4).

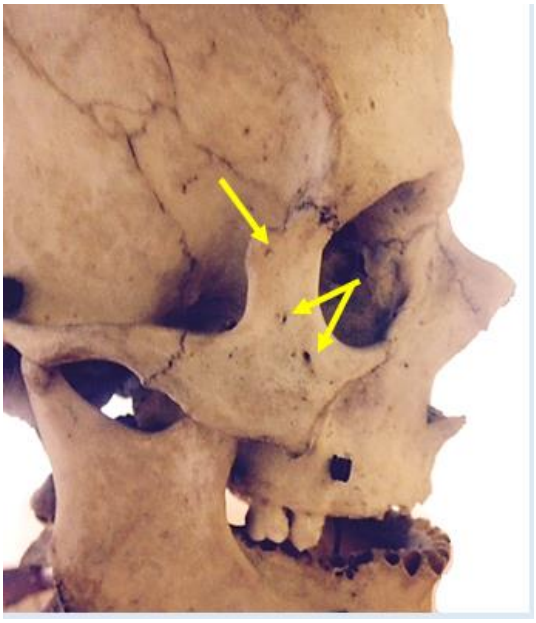

Fig 3: Craniometric study. Dolichocephalic structure of the skull. On the facial surface of the zygomatic bone there are three zygomaticofacial foramina, one of which is close to the zygomaticofrontal suture (shown with arrows)

Fig 4: Craniometric study. Brachycephalic structure of the skull. Most of the zygomaticofacial foramina are centered near the lower-outer edge of the orbit. One of the zygomaticofacial foramina was shifted from the orbit to the zygomaticotemporal suture (shown with arrows)

The most often (50 observations), on both sides of the skulls of different shapes, there were two zygomaticotemporal foramina that were located 1.4 - 2, 3 cm below the frontozygomatic suture (1.79 ± 0.18 cm) and 1.8 - 2.5 cm (2.17 ± 0.15 cm) more medially from the zygomaticotemporal suture. In 16 cases, there were three foramina on the temporal surfaces of the zygomatic skull bones, which localized "fan-like" and asymmetric (Fig. 5). Most often they were found in brachiocephals (7 cases) and mesocephals (5 cases).

On two skulls that were brachiocephalic, four zygomatico-temporal foramina were found, they occupied an asymmetric position and settled at different distances from the selected reference points (Table 2). Such variability of the number of zygomatico-temporal foramina and the lack of uniformity of their location indicates the existence of two variants of the outlet of the zygomatico-temporal branches of the zygomatic nerve from the thickness of the zygomatical bone and branching in the skin of the temporal region: the multibranching and the main.

The number of skulls with mesocephalic and brachiocephalic forms of the structure, in which two or three foramina occur, were statistically significant (p<0,05) differing in number of cases when the skulls were detected with one foramen. In dolichocephalic skulls, the frequency of cases (55.9%) was prevalent when it was found one zygomatico-temporal foramen. There were no significant differences between the right and left sides (P>0,05).

Table 2: Anatomical variability of the number of zygomaticotemporal foramina depending on the types of skull structure

Type of skull structure (total number of cases)	Detected number of zygomaticotemporal foramen on the analyzed skulls (number of studied skulls,% of cases *)			
	1 foramen	2 foramina	3 foramina	4 foramina
Dolichocephalic type (34)	19 (55,9%)	11 (32,3%)	4 (11,6%)	Not detected
Mesochephalic type (40)	13 (32,5%)	22 (55,0%)	5 (12,5%)	Not detected
Brachycephalic type (18)	Not detected	9 (50,0%)	7 (38,9%)	2 (11,1%)

Note: * - The percentage of cases in each group was counted according to the total number of skulls that had the same type of structure.

Fig 5: Craniometric study. Brachycephalic structure of the skull.

On the temporal surface of the zygomatical bone there are three zygomatico-temporal foramen in which the probes are introduced.

Taking into account the results of craniometric studies as well as the individual topographic and anatomical features of zygomaticofacial nerve branching in people with different types of skull structure, we have developed the technique of conduction anesthesia of the branches of the zygomaticofacial nerve. The facial surface of the zygomatic bone resembles a scalene quadrangle, which differs in the form in each person, depending on the type of structure of the skull. Therefore, anatomical landmark for anesthetic injection is determined individually in each patient. It is located at the intersection of two imaginary lines, which connect the opposite corners of the quadrangle: a vertical, drawn from the zygomaticofrontal suture to the lower corner of the zygomatic bone and the horizontal, drawn from the zygomaticotemporal suture to the zygomaticomaxillary suture (Fig. 6). Zygomaticofacial foramina are located within the imaginary ellipse, the center of which is the place of the needle injection. The average distance to these openings along the large semiaxis is 10.4 ± 4.8 mm, and 5.7 ± 1.5 mm along small one.

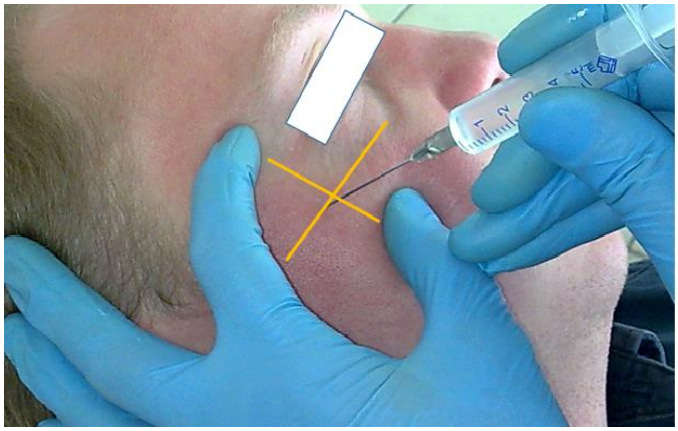

Fig 6: Blockade of the zygomaticofacial nerve (results of our research)

In people with mesoprosopnic face shape (mesocephalic skulls), a local anesthetic (1.0 ml) is injected after the needle insertion into a definite anatomical landmark. In patients with leptoprosopnic face shape (dolichocephalic skulls) in order to exhaust all branches of the facial nerve needle after inclination should be pushed forward by 1.0 - 1.5 cm vertically towards the frontal joint. In patients with euriprosopnic face shape (brachycephalic skulls), to block the branches of the zygomaticofacial nerve in the place where they reach the surface of the zygomatic bone, the needle should be directed horizontally 1.0-1.5 cm towards the zygomaticotemporal suture.

The results of our craniometric studies have also been used in the development of the method of conductive anesthesia of the zygomaticotemporal nerve. It comes out from the thickness of the zygomatical bone and penetrates the soft tissues below the zygomatico - frontal suture, which is well palpated, so this anatomical formation is a convenient guide for determining the location of the needle injection.

An imaginary line drawn between two guide-marks: fronto-zygomatical and zygomatico-temporal sutures, intersects the course of the branches of the zygomatico-temporal nerve in their direction to the temporal bone [15]. The technique of anesthesia itself is carried out in the following way: the needle is injected at the level of the fronto-zygomatical suture. Next along this line, in which the subcutaneous adiposal tissue above the surface of the superficial fascia leaf, "creep" infiltration with anesthetic solution (2.5 - 3.0 ml.), reaching the upper edge of the visual arc (Fig. 7).

Fig 7: Blockade of the zygomaticotemporal nerve (results of our research).

The needle injection is carried out at the level of the fronto-zygomatical suture (SFZ) in the thickness of the subcutaneous adipose tissue and moves towards the upper edge of the zygomatic arc (AZ).

Discussion: The results of craniometric research of topographic anatomical peculiarities of zygomaticofacial foramina location on the facial surface of the zygomatic bone turned out to be similar to the data of other authors regarding the variability of quantity and orderliness of zygomaticofacial foramina location [16-21]. There is great variability regarding the site of nerve division outside/inside the zygomatic bone and the number of foramina/canals where nerves enter and leave the zygomatic bone [19]. The external surface of the zygomatic bone ususally has one or two zygomaticofacial foramina. However, literary data varies regarding the frequency of cases when it was found three zygomaticofacial foramina. The majority of researchers notes the low level of such frequency – from 2,14% to 4,0% of cases [18, 20, 21]. Our results of research are akin with the results of Hwang SH *et al*. – this author revealed three zygomaticofacial foramina in 9% of cases [16]. The results of our craniometric study of the orderliness of location of zygomaticofacial foramina regarding constant anatomical landmarks – zygomaticofrontal suture, zygomaticotemporal suture and outer edge of the orbit are similar to the data of Mangesh L. and Ferro A, *et al*. according to which zygomaticofacial foramina are usually located near lower-outer edge of the orbit [20], but take place in the so-called ZFF zone (diameter of the zone = 25 mm) at the different distance regarding the anatomical landmark that is the center of the facial surface of the zygomatic bone [21]. A pilot study, conducted on the same number of patients, concluded that the main zygomaticotemporal branch emerges from the deep temporal fascia at a point on average 17 mm lateral and 6mm cephalad to the lateral palpebral commissure, commonly referred to as the lateral canthus. Three types of accessory branches were found in relation to the main branch: (1) accessory branch cephalad, (2) accessory branch lateral, and (3) accessory branches in the immediate vicinity of the main branch.These measurements, however, were obtained after dissection of the temporal area, rendering the findings less reliable [22]. The anterolateral scalp cutaneous nerves were examined in adult cadavers.three types of zygomaticotemporal nerve branches were found. The zygomaticotemporal nerve pierced the deep temporalis fascia 10 mm posterior to the frontozygomatic suture (range, 7-13 mm) and 22 mm above the upper margin of the zygomatic arch (range, 15-27 mm) [15]. The zygomaticotemporal branch of the trigeminal nerve has been shown clinically to have sites of entrapment within the temporalis. A cadaveric study was undertaken to elucidate and delineate the location of this nerve's foramen and intramuscular course. In exactly half of all specimens, the nerve had no intramuscular course. In the other half, the nerve either had a brief intramuscular course or a long, tortuous route through the muscle. The foramen was located at an average of 6,70 mm lateral to the lateral orbital rim and 7,88 mm cranial to the nasion-lateral orbital rim line, on the lateral wall of the zygomatic portion of the orbit. Two branches were sometimes seen [23].

However, these authors did not aim to find the connection between the topographic anatomical peculiarities of zygomaticofacial and zygomaticotemporal foramina location and the types of face shape that could have the practical value while choosing the anatomical landmarks during the blockade of zygomaticofacial and zygomaticotemporal nerves. The successful anesthesia of this nerves allows to do the surgical intervention painlessly not only in zygomatic, but also in temporal and buccal areas.

Conclusions: The location and amount of zygomaticofacial and zygomaticotemporal foramina vary depending on the shape of the skulls. It was found that the most distinguished among the amount and location of these holes are dolichocephalic and brachiocephalic skulls. In the development of methods of conducting anesthesia of zygomaticofacial and zygomaticotemporal nerves, individual anatomical features of their branching in the zygomatic and temporal areas were taken into account.

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