TOPOGRAPHIC AND ANATOMICAL ASPECTS OF THE DEVELOPMENT OF THE TECHNIQUE OF CONDUCTIVE ANESTHESIA OF THE ZYGOMATICOFACIAL NERVE AND EVALUATION OF ITS EFFECTIVENESS UNDER CLINICAL CONDITIONS

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Abstract

Introduction. Branching of the trigeminal nerve on the face has individual anatomical variability. Individual variability of innervation in the soft tissues of the maxillofacial area should be taken into account during their local anesthesia. The purpose of the study was to develop a method of conductive anesthesia of the zygomaticofacial nerve, taking into account its individual topographic and anatomical features, and to evaluate its clinical effectiveness. **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 a multi-detector row spiral computer tomographer. A new method of conductive anesthesia of the zygomaticofacial nerve was applied on 30 stationary patients, comparing its effectiveness with that of a known method. **Results and discussion.** Based on the results of craniometric studies, as well as on the individual topographic and anatomical features of zygomaticofacial nerve branching in people with different types of skull structure, the technique of conductive anesthesia of the branches of the zygomaticofacial nerve was developed. **Conclusions.** Application, under clinical conditions, of the technique of conductive anesthesia of the zygomaticofacial nerve, developed by us, in combination with the classical method of local anesthesia of the buccal nerve provides painless surgical interventions on the lateral area of the face.

Keywords: *zygomaticofacial nerve, craniometric studies, conductive anesthesia, face shape.*

1. INTRODUCTION

As generally known, 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. Branching of the trigeminal nerve on the face has an individual anatomical variability, dividing it into two types [3].

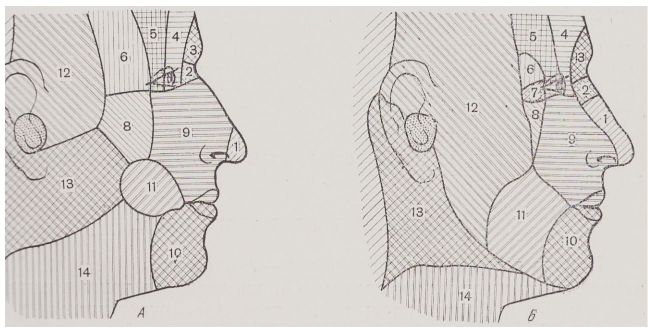

Fig.1. Types of branching on the face of the superficial branches of the trigeminal nerve and cervical nerve plexus (according to V.N. Shevkunenko)
A – with domination of the superficial branches of the maxillary nerve and cervical nerve plexus on the face;
B – with domination of the superficial branches of the mandibular nerve on the face
1 – external nasal branch of the 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, face innervation is dominated by the superficial (zygomaticofacial and infraorbital) branches of the maxillary nerves, involved in sensitive innervation of the cheek area. The second type is dominated by superficial (buccal and mental) sensory branches of the mandibular nerves involved in the sensitive innervation of the cheek area [3]. Here, the buccal nerve forms a plexus with the facial nerve, the infraorbital nerve and the 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 the soft tissues of the zygomatic area, besides the conductive anesthesia of the buccal nerve, we blocked the zygomaticofacial nerve, according to a technique through which the anesthetics is injected at the lower outer edge of the orbit [8-10], where the zygomaticofacial foramina are located, and through which the branches of the zygomaticofacial nerve protrude from the zygomatic bone [11]. However, the buccal and zygomatic areas were completely anesthetized in 74% of cases. In 26% of cases revealed clinically with uncomplete anesthesia of the buccal and zygomatic areas, we noticed that only the central part of the zygomatic region, and only the small area near the lower outer edge of the orbit were anesthetized. The upper part of the zygomatic region near the zygomaticofrontal suture, as well as the lateral part near the zygomaticotemporal suture remained sensitive. 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 nerve on the face. These patients were broad-faced or long-faced.

Purpose of the study: to develop a method of conductive anesthesia of the zygomaticofacial nerve, taking into account its individual topographic and anatomical features, and to evaluate its effectiveness under clinical conditions.

2. MATERIALS AND METHODS

Craniometric studies were performed on 32 natural skulls of corpses of various ages, and 60 images of the head section of patients were done in a 3D reconstruction by an Aquilion multi-detector row spiral computer tomographer (Toshiba Medical Systems, Japan). The cranial index represents the percent correlation between the transverse (width) of the face and the longitudinal diameter (length). If the index is more than 80.9%, then this form of the skull should be attributed to the brachycephalic (short-headed), if it is within 76-80.9% – to the mesocephalic (medium-headed) one. 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 by counting the number of zygomaticofacial foramina on each skull and by observing 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 and the proposed anatomical landmark for injection on the side (facial) surface of the zygomatic bone.

30 stationary surgical stomatological patients with planned surgical interventions on the lateral facial area (in the buccal area - 18 patients, in the zygomatic area - 12 patients) that gave their written a consent beforehand, took part in the clinical observation. We applied a method of conductive anesthesia of the zygomaticofacial nerve and compared its effectiveness with a known method [8-10], applied in 31 patients exposed to surgical interventions in cheek (17 cases) and zygomatic (14 cases) areas. In order to detect the individual anatomical features of the facial part of the head, the facial index was determined by Garson`s formula, as the relation between the morphological height of the face and its width multiplied by 100. The numeric value of the facial index: 79.0-83.9 defines the broad face (euriprosopne); 84.0-87.9 – middling face (mesoprosopne); 88.0-92.9 and more – oblong face (leptoprosopne) [12,13]. In most of the cases, the euriprosopnic face shape responds to the brachycephalic skull, the mesoprosopnic face shape – to mesocephalic skull and the leptoprosopnic face shape – to dolichocephalic skull, respectively [3].

The zygomatic area was divided into four quadrants: upper-front, upper-back, lower-front and lower-back by means of imaginary, mutually perpendicular lines, carried through its center. The buccal area was also divided into quadrants in a similar manner. Tactile sensitivity was investigated using nylon monofilaments. Pain sensitivity was determined by injection of a needle (pinprick) into the epidermis. Assessment of tactile and pain sensitivity was performed on a four-point scale in each quadrant: 0 points – no sensitivity, 1 point – sensitivity is sharply reduced, 2 points – sensitivity is moderately reduced, 3 points – tactile and pain sensitivity is completely preserved. In cases of pathological processes (benign tumors, keloid scars, fistulas of migrating granulomas) located in the buccal region, surgical interventions were conducted under local conduction anesthesia of the buccal and zygomaticofacial nerves. Anesthesia of the buccal nerve was carried out through the skin, according to the method of Yegorov [14], the anesthetics being injected at the anterior edge of the base of the coronary process of the mandible, where the buccal nerve passes.

The protocol used in this study observed the Declaration of Helsinki, being approved by the Ethics Committee of the Danylo Halytsky Lviv National Medical University.

Data was analysed by means of Pearson's chi-square tests. The probability of the obtained results was evaluated according to Student probability criterion, by statistically computing the data using common methods of statistics from the package "Statistica-7".

3. RESULTS

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

Table 1. Anatomical variability in the number of zygomaticofacial foramina depending on 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 with the same type of structure.

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

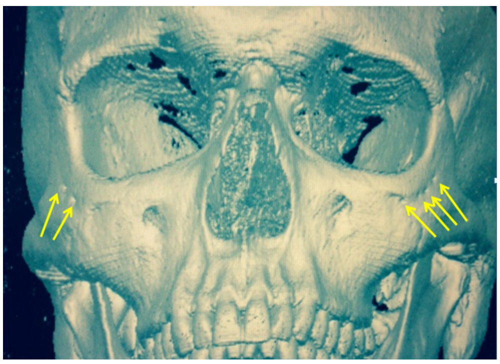

Fig. 2. Computer tomography of the facial skull in 3D reconstruction. Craniometric study. Mesocephal structure of the skull. Four zygomaticofacial foramina are present on the facial surface of the zygomatic bone on the left side and two zygomaticofacial foramina on the right side (shown with arrows).

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 appear at different distances between each other, close to the zygomaticofrontal suture at 6.9 ± 2.3 mm (Fig. 3).

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

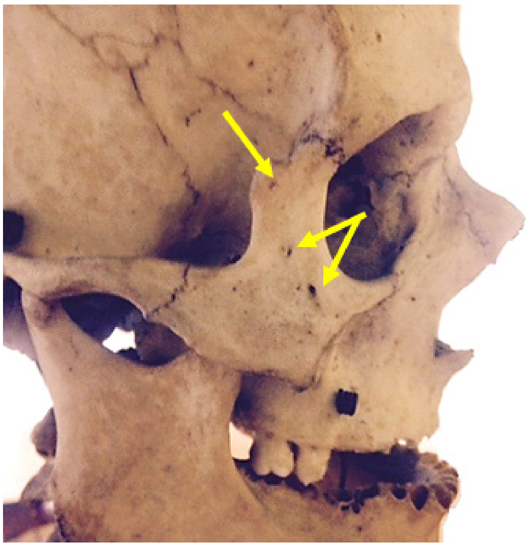

Fig. 3. Craniometric study. Dolichocephalic structure of the skull. Three zygomaticofacial foramina occur on the facial surface of the zygomatic bone, one of which close to the zygomaticofrontal suture (shown with arrows)

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 shifted from the orbit to the zygomaticotemporal suture (shown with arrows)

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 form in each person, depending on the type of skull structure. Therefore, the anatomical landmark for anesthetic injection is determined individually in each patient, being located at the intersection of two imaginary lines, which connect the opposite corners of the quadrangle: a vertical one, drawn from the zygomaticofrontal suture to the lower corner of the zygomatic bone, and a horizontal one, drawn from the zygomaticotemporal suture to the zygomaticomaxillary suture (Fig. 5). Zygomaticofacial foramina are located within the imaginary ellipse, the center of which is the place of needle injection. The average distance to these openings along the large semiaxis is 10.4 ± 4.8 mm, and 5.7 ± 1.5 mm, respectively, along the small one.

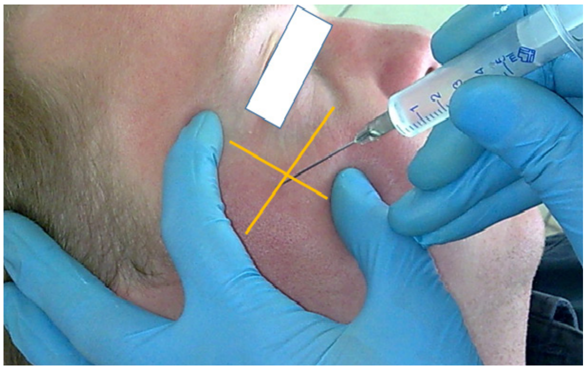

Fig.5. Blocking of the zygomaticofacial nerve (results of our research)

In people with mesoprosopnic face shape (mesocephalic skulls), a local anesthetics (1.0 ml) is injected after needle insertion into a definite anatomical landmark. In patients with leptoprosopnic face shape (dolichocephalic skulls), for exhausting all branches of the facial nerve, after inclination, the needle 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 effectiveness of the developed method of conducting anesthesia of the zygomaticofacial nerve was studied under clinical conditions. After blocking of the buccal nerve in 18 patients with various face shape before surgical interventions in the cheek area, it was found out that, in 10 patients (55.6 % of cases), complete buccal anesthesia did occur. In 8 patients (44.4% of cases), the cheek area was anesthetized only partially: tactile and pain sensitivity remained in the upper part of the cheek area – 1.5 ± 0.5 points ($p > 0.05$). After an additional blockage of the branches of the zygomaticofacial nerve, according to the developed technique, complete anesthesia of the above-mentioned topographic anatomical site occurred in all patients, independently on face shape: tactile sensitivity - 0-1 points, pain sensitivity - 0 points ($p < 0.05$). After blocking of the zygomaticofacial nerve in 12 patients with various face shape before surgical interventions in the zygomatic region, it was found out that, in 100 % of cases, complete anesthesia in the zygomatic area occurred: tactile sensitivity - 0 points, pain sensitivity - 0 points ($p < 0.01$) (Table 2).

The loss of tactile and pain sensitivity on the skin of the buccal and zygomatic regions absolutely confirmed the effectiveness of the developed method of local conduction anesthesia. During surgical treatment, effectiveness of the local anesthetic methods was evaluated as good – stable anesthesia was observed in patients, without psychosomatic peculiarities or local and general complications.

In 14 patients of the control group, before surgical interventions in the zygomatic region after anesthesia of the zygomaticofacial nerve by a known method, complete anesthesia occurred in 7 patients with mesoprosopnic face shape and in 2 patients with leptoprosopnic face shape ($p < 0.01$). In 5 patients, complete anesthesia was not achieved: tactile and pain sensitivity remained in the zygomatic region – 2.0 ± 0.5 points ($p > 0.05$). Among them, 3 patients had with leptoprosopnic face shape and 2 - euriprosopnic face shape. In 10 patients of the control group, before surgical interventions in the cheek area after buccal nerve anesthesia by the standard method, complete anesthesia of the cheek area occurred, while, in 7 patients, pain sensitivity remained in the upper part of this topographic anatomical region –1.5 ± 0.5 points ($p > 0.05$). After additional zygomaticofacial nerve anesthesia by the known method, complete anesthesia of the cheek area occurred in 5 patients with mesoprosopnic and leptoprosopnic face shapes. In 2 patients with euriprosopnic face shape, pain perception remained in the upper part of the cheek (Table 2). The results of the Chi-square analysis are listed in Table 3.

This situation confirms that introduction of local anesthetics to block the zygomaticofacial nerve by the known method near the lower-outer edge of the orbit allows achieving the needed effect only in patients with mesoprosopnic face shape. In order to anesthetize this nerve in people with broad and oblong face shape, anatomical variability of its branching should be considered.

Table 2. Effectiveness of the applied anesthesia methods of zygomaticofacial nerve

Groups of patients depending on the applied method of anesthesia of zygomaticofacial nerve		Appearance of anesthesia of the soft tissues after blocking of the zygomaticofacial nerve (number of cases)	
		Zygomatic area	Upper part of the buccal area
Experimental group (anesthesia of zygomaticofacial nerve by the developed method) (n=20)	Patients with euriprosopnic face shape (n=5)	Anesthesia occured – 3 cases	Anesthesia occured – 2 cases
	Patients with mesoprosopnic face shape (n=8)	Anesthesia occured – 4 cases	Anesthesia occured – 4 cases
	Patients with leptoprosopnic face shape (n=7)	Anesthesia occured – 4 cases	Anesthesia occured – 3 cases

Control group (anesthesia of zygomaticofacial nerve by the known method) (n=21)	Patients with euriprosopnic face shape (n=5)	Anesthesia did not occur – 2 cases	Anesthesia did not occur – 3 cases
	Patients with mesoprosopnic face shape (n=10)	Anesthesia occured – 7 cases	Anesthesia occured – 3 cases
	Patients with leptoprosopnic face shape (n=6)	Anesthesia occured – 2 cases Anesthesia did not occur – 3 cases	Anesthesia occured – 1 case

Table 3. Chi-square comparative analysis of the applied methods of anesthesia of the zygomaticofacial nerve

Comparison groups (n_1 – Experimental group; n_2 – Control group)	Experimental group (Occurrence of anesthesia, n , % of cases)	Control group (Occurrence of anesthesia, n , % of cases)	Chi-square value	P value
Patients with euriprosopnic face shape (n_1 = 5; n_2 = 5)	5 (100%)	0 %	10.0	0.002
Patients with mesoprosopnic face shape (n_1 = 8; n_2 = 10)	8 (100%)	10 (100 %)	NaN	1.000
Patients with leptoprosopnic face shape (n_1 = 7; n_2 = 6)	7 (100%)	3 (50 %)	4.55	0.033
In general for comparison groups (n_1 = 20; n_2 = 21)	20 (100%)	13 (61.9 %)	9.46	0.003

4. DISCUSSION

The results of craniometric research on the 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 [15-20]. High variability regarded the site of nerve division outside/inside the zygomatic bone and the number of foramina/canals where nerves enter and leave the zygomatic bone [18]. Usually, the external surface of the zygomatic bone has one or two zygomaticofacial foramina. However, literature data varies regarding the frequency of cases where three zygomaticofacial foramina were observed. Most of researchers note the low level of such a frequency – from 2.14% to 4.0% of cases [17,19,20]. Our results agree with the results of Hwang *et al*. (2007) [15] – who revealed three zygomaticofacial foramina in 9% of cases. The results of our craniometric study on the orderliness of the 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 (2016) and Ferro *et al*. (2017), according to whom zygomaticofacial foramina are usually located near the lower-outer edge of the orbit [19], in the so-called ZFF zone (diameter of the zone = 25 mm) at different distances from the anatomical landmark, which is the center of the facial surface of the zygomatic bone [20]. However, these authors did not aim at finding a connection between the topographic anatomical peculiarities of zygomaticofacial foramina location and the types of face shape, which could have practical value in choosing the anatomical landmarks during blockage of the zygomaticofacial nerve. The successful anesthesia of this nerve allows a painless surgical intervention not only in the zygomatic, but also in the buccal area.

The main sensory nerve of the buccal region is the (long) buccal nerve [21,22]. The skin of the upper anterior part of the cheek is supplied by the lateral rami of the large superior labial branch from the infraorbital nerve [23]. The lower part of the cheek is innervated by terminal branches from the superficial cervical plexus. The transverse cervical nerve (forming part of the superficial cervical plexus) may contribute to a cutaneous sensory innervation on the skin of the inferior border of the lateral and anterior mandible [24,25]. The clinical results of the research confirm that the upper part of the buccal area may be also innervated by the zygomaticofacial nerve. This should be considered during surgical interventions on the soft tissues of the lateral facial area.

5. CONCLUSIONS

For a successful local anesthesia of the buccal and zygomatic areas, it is necessary to take into account the anatomical variability of branching on the face of the buccal and zygomaticofacial nerves in patients with different types of skull structure and face shape. Application, under clinical conditions, of the technique of conductive anesthesia of the zygomaticofacial nerve developed by us, in combination with the classical method of local anesthesia of the buccal nerve, provides painless surgical interventions on the lateral area of the face.

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