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GRAPHICAL MODELING OF LOWER JAW SIZE RATIOS FOR TECHNOLOGICAL IMPROVEMENT OF MANDIBULAR ANESTHESIA

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Annotation. *Clinical experience shows that even small violations in the technique of performing mandibular anesthesia have a negative impact on its effectiveness. There are also a number of factors that do not depend on the skills of the doctor, but make it extremely difficult to perform it. The aim of the work was to increase the effectiveness and safety of conduction anesthesia on the lower jaw by developing a universal auxiliary tool. In the anatomical part, the anthropometric indicators of 91 dry anatomical preparations of the lower jaw of adults were studied. The X-ray part of the study was carried out using a computer tomograph Sirona ORTHOPHOS SL. The corresponding anthropometric indicators were studied on 420 tomograms and orthopantomograms of the lower jaw of adults.*

Keywords: *orthopantomogram, developmental anomalies, lower jaw.*

Currently, conduction anesthesia is the most common method of local anesthesia for the main types of dental treatment in the lower jaw. The term "mandibular anesthesia" refers to various techniques for performing conduction anesthesia near the mandibular foramen, the purpose of which is the reversible interruption of nerve conduction in the corresponding areas of the target nerves (inferior alveolar, lingual, buccal). Most of the techniques require the determination of about 10 anatomical and topographic landmarks, which makes them difficult.

Clinical experience shows that even small violations in the execution of the technique have a negative impact on its effectiveness. There are also a number of factors that do not depend on the skills of the doctor, however, it is extremely difficult to perform mandibular anesthesia. These include individual anatomical, physiological and behavioral characteristics of the patient. All this causes its insufficient efficiency, which, according to a number of authors, ranges from 60 to 85 %. The solution to the problem can be the development of a universal auxiliary tool to improve clinical orientation and reduce the influence of local adverse factors based on the study of the anthropometric parameters of the lower jaw and graphical modeling of the ratio of its main dimensions.

Aim of the study. To increase the effectiveness and safety of conduction anesthesia in the lower jaw by developing a universal auxiliary tool - provider based on the study of the necessary anthropometric parameters of the lower jaw and graphical visualization of the direction of the needle vector using the Back Low method [1-5].

Materials and methods. The anatomical part of the study was carried out on the basis of the Department of Normal and Pathological Human Anatomy of the Odessa National Medical University. Anthropometric parameters of 91 dry anatomical preparations of the lower jaw of adults were studied.

The X-ray part of the study was carried out on the basis of the SE "ISMFS NAMS" of Ukraine using a Sirona ORTHOPHOS SL computer tomograph. The corresponding anthropometric parameters were studied on 420 tomograms and orthopantomograms of the lower jaw of adults.

To study the ratio of jaw sizes and the presence of relationships between them, a correlation analysis was carried out using the linear Pearson correlation coefficient, which is used to study the relationship between two variables measured in metric scales on the same sample. To assess the correlation coefficient, the Chaddock scale was used.

The "KOMPAS-Graph v21" program was used to visualize the obtained data and calculate accompanying values. The calculated model was based on the previously obtained average values of the correlating parameters.

Results and discussion. To study anthropometric indicators, a number of parameters were determined, which are the main landmarks for anesthesia using the Back Low method. First of all, it was noted that the horizontal plane passing through the teeth of the lower jaw, in the absolute majority of cases, crosses the funnel of the mandibular canal - the area where the lower alveolar nerve enters the body of the lower jaw. This ratio is maintained with partial or complete adentia, as well as atrophy of the lower jaw. Exceptions may be pathologies and anomalies in the development of the lower jaw, fractures, severe cases of involutive atrophy. This relationship is well observed on orthopantomograms and can be measured. In cases where the horizontal plane passing along the upper anatomical point of the alveolar part or teeth crossed the funnel region of the mandibular canal, the value was considered as 0. If this area was higher, the number of millimeters with a "+" sign was taken into account, if it was lower – with a "-" sign. So, when studying 420 orthopantomograms, the average value was +0.14 mm.

In turn, the measurement of the dimensions of the funnel region of the mandibular canal showed that its average height is 10.8 mm, and the length is 8.5 mm. Thus, the funnel region of the mandibular canal is a distally inclined ellipse, expanding in the upper part, at the base of which there is a mandibular opening displaced anteriorly to the border of the first and second third of the length of the funnel region, partially covered by a bone protrusion or a thin plate (uvula). When studying dry anatomical preparations of the human lower jaw, it was noted that this uvula is more common and better expressed at a young age. The bony uvula was weakly expressed or absent on the preparations, where there were signs of involutive atrophy and loss of teeth. During the measurements, it was noted that the dimensions of the funnel region of the mandibular canal do not depend on the degree of atrophy of the lower jaw and, on average, remain the same as at a young age, but their boundaries are less pronounced.

It was also noted that the point located at the top of the internal oblique line at the point of its transition from the alveolar part to the inner surface of the mandibular branch (point BL) is in the horizontal plane at the level of the lower border (or slightly below) of the funnel region of the mandibular canal. So the average value here was – 0.29 mm.

This point is an important landmark for conducting anesthesia using the Back Low method in clinical practice, as it is covered with a layer of attached gums and is located at the site of its transition to the soft tissues of the peripharyngeal region, which makes it easy to visually or palpate this landmark. Also clinically important, for identifying possible relationships, is a number of anthropometric measurements:

A – distance between mandibular foramen;
B – distance between internal oblique lines;
C – distance between outer oblique lines;
D – distance from internal oblique line to external oblique line;
E – distance from the internal oblique line to the mandibular foramen;
F – distance from the extreme anterior point of the funnel region of the mandibular canal to the alveolar septum of 31-41 teeth or the mental symphysis in case of adentia.

The measurements were carried out in the horizontal plane corresponding to the level of the BL point (Fig. 1).

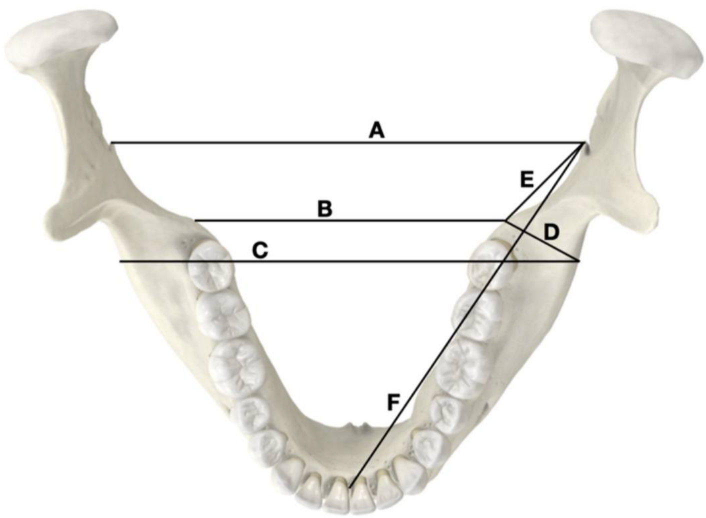

Fig. 1. Image of the studied anthropometric values on the lower jaw.

A – distance between mandibular foramen;
B – distance between internal oblique lines;
C – distance between outer oblique lines;
D – distance from internal oblique line to external oblique line;

E – distance from the internal oblique line to the mandibular foramen;

F – distance from the extreme anterior point of the funnel region of the mandibular canal to the alveolar septum of 31-41 teeth or the mental symphysis in case of adentia.

To calibrate the measurements of 10 dry preparations, tomography was performed and the measurement results were compared using a physical measuring device (caliper) and virtual meters in the tomography viewer. The results obtained from the measurement of dry preparations and tomograms were combined, and their average values are presented in Table 1.

Table 1

Mean measurements on the lower jaw

Line measurement	A	B	C	D	E	F
Average value, mm	83.72	62.24	79.50	10.65	13.90	72.04
Standard deviation, mm	4.29	3.82	4.54	1.62	2.32	4.98

The main objective of this study was to establish not only the average values of a number of parameters in the lower jaw, but also to evaluate their possible relationship. The results of a linear correlation analysis of a number of anthropometric values in the lower jaw are presented in Table 2.

Table 2

The results of a linear correlation analysis of a number of anthropometric values in the lower jaw (r-Pearson)

Measurement line	A	B	C	D	E	F
A	-	0.63	0.78	-0.11	0.58	0.80
B		-	0.68	-0.41	0.21	0.59
C			-	0.12	0.34	0.55
D				-	0.01	0.06
E					-	0.78
F						-

It follows from the obtained data that the correlation dependence between the obtained values is rather non-uniform. Thus, a high relationship is determined between lines A and F (0.80), A and C (0.78), E and F (0.78). The average relationship is determined between the values of A and B (0.63), A and E (0.58), B and C (0.68), B and F (0.59), C and F (0.55). A weak relationship was found between C and E values (0.34). Correlation analysis of the values B and E (0.21), C and D (0.12), E and D (0.01), D and F (0.06) showed a very weak relationship. Values A and D (-0.11), B and D (-0.41) showed a very weak and weak inverse relationship, respectively. To solve the problem of improving the safety and efficiency of conduction anesthesia in the lower jaw by improving the accuracy of injection by developing an additional device, one should rely on values with a high relationship or close to it. It is also necessary to take into account the influence of intraoral factors.

Next, a graphical visualization of the obtained data was carried out, in which the previously obtained average values of the correlated parameters of the lower jaw were taken as the basis for the calculation model (Fig. 2).

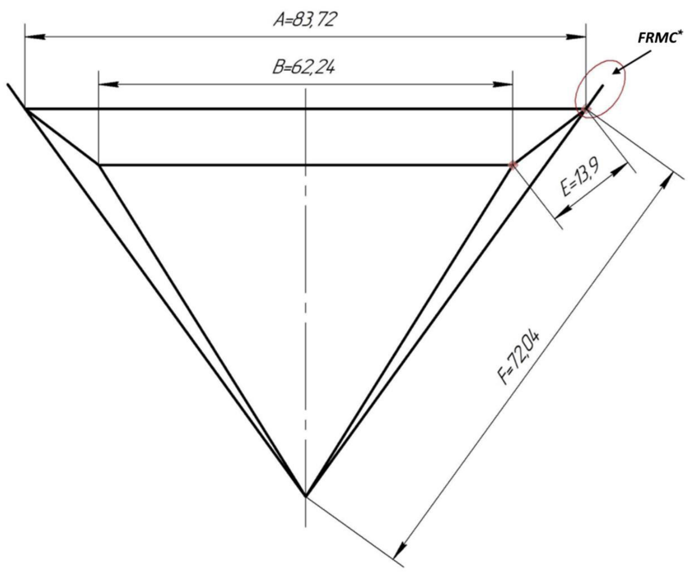

Fig. 2. Graphical visualization of the values and ratios of the studied quantities in the lower jaw

*FRMC – funnel region of mandibular canal

When analyzing this graphical visualization, it seems possible to determine a number of additional parameters. In particular, the average value of the EAF angle, the apex of which is the mandibular foramen, was 12.34 degrees. It should be noted that the value of this angle in the analysis of all jaws ranged from 2 to 51.4 degrees and did not correlate with any of the measured values. This indicates that the direction of the needle stroke along the average value, which is the basis of various modifications of mandibular anesthesia, does not at all guarantee the accuracy of the injection and, as a result, its effectiveness and safety. The size of the funnel region of the mandibular canal allows for a certain error during anesthesia, however, graphic modeling with an "average" angle showed that the needle reached the funnel region only in half of the cases. In other cases, the contact of the conditional needle occurred anterior to the target or the needle passed tangentially posteriorly without contact with the bone.

The distance from the mandibular foramen to the BL point (line E) is a much more stable parameter. Graphical modeling has shown that an increase in the angle of attack and a shift in the direction vector posteriorly along the line E can significantly increase the accuracy. So, with an increase in the angle of attack to 27.2 degrees and a displacement of the needle movement vector posteriorly by 5 mm, the funnel region is crossed in 84 % of cases. The remaining 16 % of cases were in the jaws, where the length of the E line was greater than 16 mm. In these cases, the motion vector passed anterior to the funnel zone. Subsequent modeling with a further increase in the angle of attack and a displacement of the needle motion vector posteriorly showed a decrease in the percentage of hits, due to the passage of the needle posteriorly from the funnel zone. It should also be noted that such distalization of the injection vector and an increase in the angle of attack can cause difficulties in clinical practice, which will be associated with a gag reflex and insufficient mouth opening.

Thus, we considered the achieved parameters to be optimal in order to base the design of the auxiliary device. Its task is to serve as a directing (provider) for the needle when performing mandibular anesthesia using the Back Low technique, and also to hold the patient's tongue.

Based on the data obtained above and clinical experience, we have developed a model shown in figure 3.

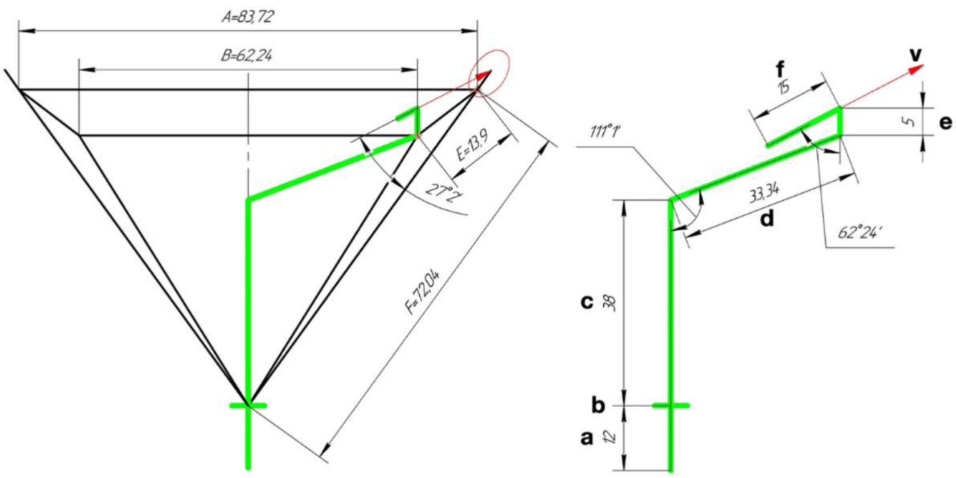

Fig. 3. Graphic visualization of provider parameters, mm

a – holder; в – incisal mark; c,d – tongue holder; e – directing pilot; f - directing funnel; v – needle direction vector.

It is assumed that this provider will have two points of support in the oral cavity − the point of contact of parts d and e (which corresponds to the point BL) and the point between teeth 31 and 41 or on the midline in case of their absence (incisal mark). Based on the calculations, this should ensure that the needle contacts the infundibulum in 84 % of cases (Fig. 4). It should be noted that the position of the provider should always be parallel to the midline, also the incisal mark not matching the center line may indicate a deviation of the needle vector from the target. In the remaining cases, the needle will contact the bone anterior to the target, which will be clinically manifested by a small advance of the needle in the soft tissues to contact with the bone (less than 13 mm) or a further absence of pulpal anesthesia in the presence of numbness of the tongue (Fig. 4). To solve this problem, it was possible to change the angle of attack by turning the provider in the direction of anesthesia. With this shift, the BL point is the axis of rotation, and the handle of the provider is shifted from the center line towards anesthesia.

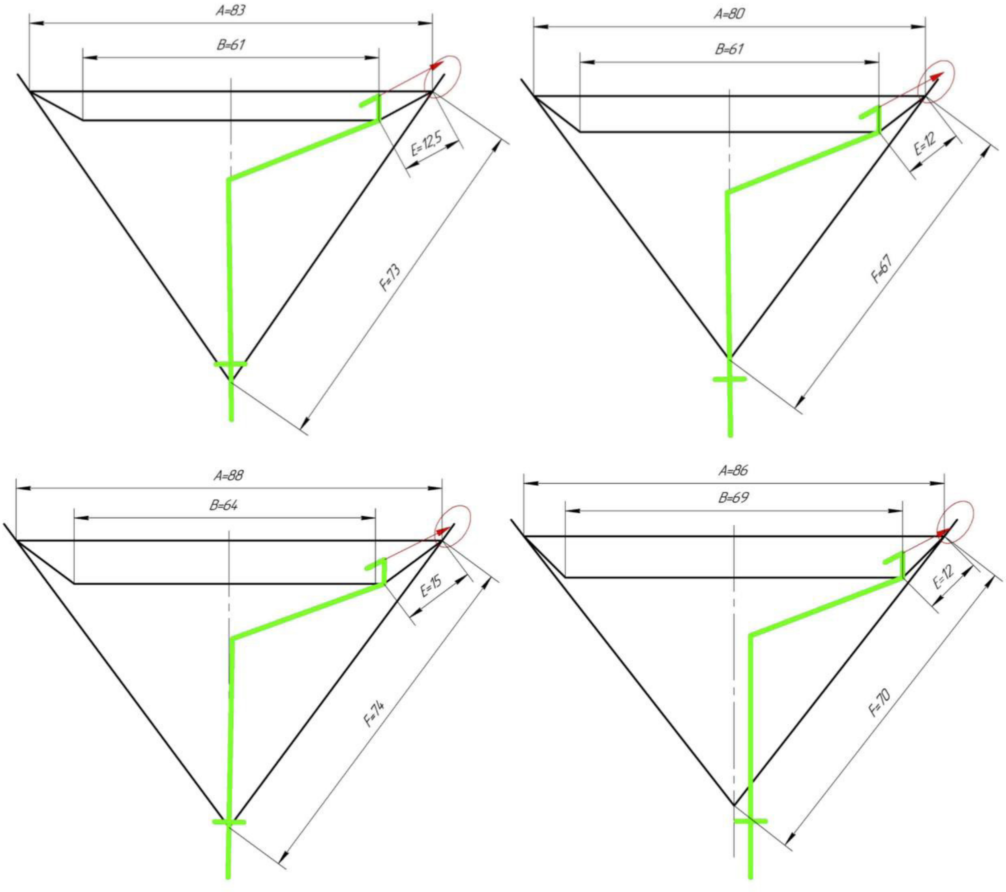

Fig. 4. Graphical visualization of the direction of the needle vector in the standard position of the provider and various parameters of the lower jaw.

Graphical modeling showed that with such a displacement of 12.5 mm, the motion vector of the needle falls within the boundaries of the funnel area in all cases considered (Fig. 5).

It should be noted that these calculations are theoretical and do not take into account some clinical features, such as gingival thickness at the BL point, which can be 1-3 mm, or an error in the placement of the provider. However, in these calculations, we determined

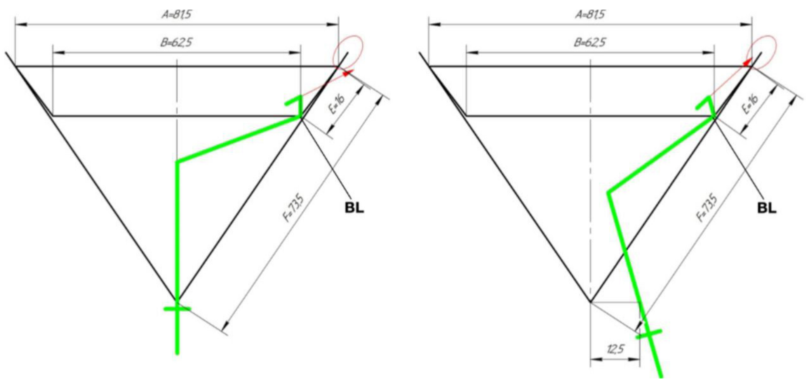

Fig. 5. Graphical simulation of the change in the angle of attack when the provider is rotated towards anesthesia.

the standard deviations (table 1), the values of which are comparable with the magnitude of the influence of these negative factors.

The next stage in the development of the provider was the creation of a 3D model based on the obtained above parameters.

Conclusions. The established ratios of the dimensions of the lower jaw with a high correlation were the basis for further graphic modeling, on the basis of which additional geometric parameters were determined, which made it possible to significantly increase the accuracy of the angle of attack of the injection needle. This was the basis for the development and creation of a 3D model of the “Back Low provider” auxiliary device, which provides tongue fixation, distalization of the needle injection point and optimization of the angle of attack during conduction anesthesia in the lower jaw.

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