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Original Research Article **Orthodontics**

A Method for Studying the Size and Position of the Apical Bases of the Jaws Using Computed Tomography of the Jaws

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Abstract

The study of the apical bases has been relevant in orthodontics for many decades; its study was carried out both on jaw models and on lateral cephalograms. Dentistry today is impossible without three-dimensional studies, which allows you to study an object from any angle and visualize the smallest changes in the anatomical structures of the area under study. The use of cone beam computed tomography to study the apical bases of the jaws makes it possible to study the configuration, size, and position of both the bases themselves and the structures that form them. The parameters we proposed allow us to study the width, length and angle of inclination of the apical base on single CBCT sections. Clinical use of the proposed analysis will contribute to more complete and accurate orthodontic treatment planning.

Keywords: Apical base, computed tomography, analysis of the apical bases of the jaws.

INTRODUCTION AND NOVELTY

Methods for clinical examination of patients with various anomalies of the dentofacial system are varied and interchangeable [1-3]. X-ray methods play a leading role in diagnostics. But the anatomical features of the maxillofacial region limit the possibilities of using classical two-dimensional x-ray examination, since the relationship and spatial position of some anatomical structures do not allow them to be studied using a two-dimensional projection [1-8]. As high technologies were introduced into practice, digital imaging methods also developed. The use of cone beam computed tomography (CBCT) has expanded diagnostic capabilities [2, 8-11]. Currently, CBCT has become one of the most popular diagnostic methods, as it has the following advantages: the object under study is scanned completely, it is possible to study the object from any angle, at any depth in the absence of the patient, and the radiation dose to the patient is reduced. The program makes it possible to visualize the smallest changes in the anatomical structures of the area under study. Computed tomography provides effective information about the localization of vital structures, the level and amount of bone tissue in any area during diagnosis and at any stage of orthodontic treatment [8, 9, 12]. Cone beam computed tomography was developed specifically for imaging hard tissues of the maxillofacial region and is capable of providing submillimeter resolution in high-quality images with a short scan mode (10–70 s) and a radiation volume 15 times lower than conventional CT [13-15].

DATA ON THE RESEARCH METHODOLOGY

The study of the apical bases of the jaws has always been of interest to medical researchers. In the literature you can find many publications on this topic.

R.J.DiPaolo and co-authors proposed a method of quadrilateral analysis of lateral cephalograms of the head, according to which the lengths of the apical basis of the upper (A'M') and lower (B") jaws with normal occlusion are equal to each other, as well as the half-sum of the anterior (A'B') and posterior (M") heights of the lower third of the face (A'M' B'J' A'B'+M'J'/2). Using this

method, it is possible to identify disorders in the development of the apical base of the jaws, characteristic of distal occlusion [16-19].

In 2011, to assess skeletal discrepancy of the jaws, a group of researchers led by Professor R.Vannarsdall at the University of Pennsylvania developed the Penn analysis using Computer Tomography scans of the jaws. When carrying out this method, the distance between the molars of the lower jaw is measured, the landmark is the vestibular cortical plate at the level of the molar bifurcation, then the transversal size of the upper jaw is measured between the lower points of the zygomatic alveolar ridge. Normally, the width of the upper jaw should be 5 mm more than the lower. If the difference is 2–5 mm, orthodontic correction is possible by changing the inclination of the lateral group of teeth, provided that optimal occlusion can be achieved; if the difference is more than 5 mm– orthodontic correction should be applied using surgical techniques [20].

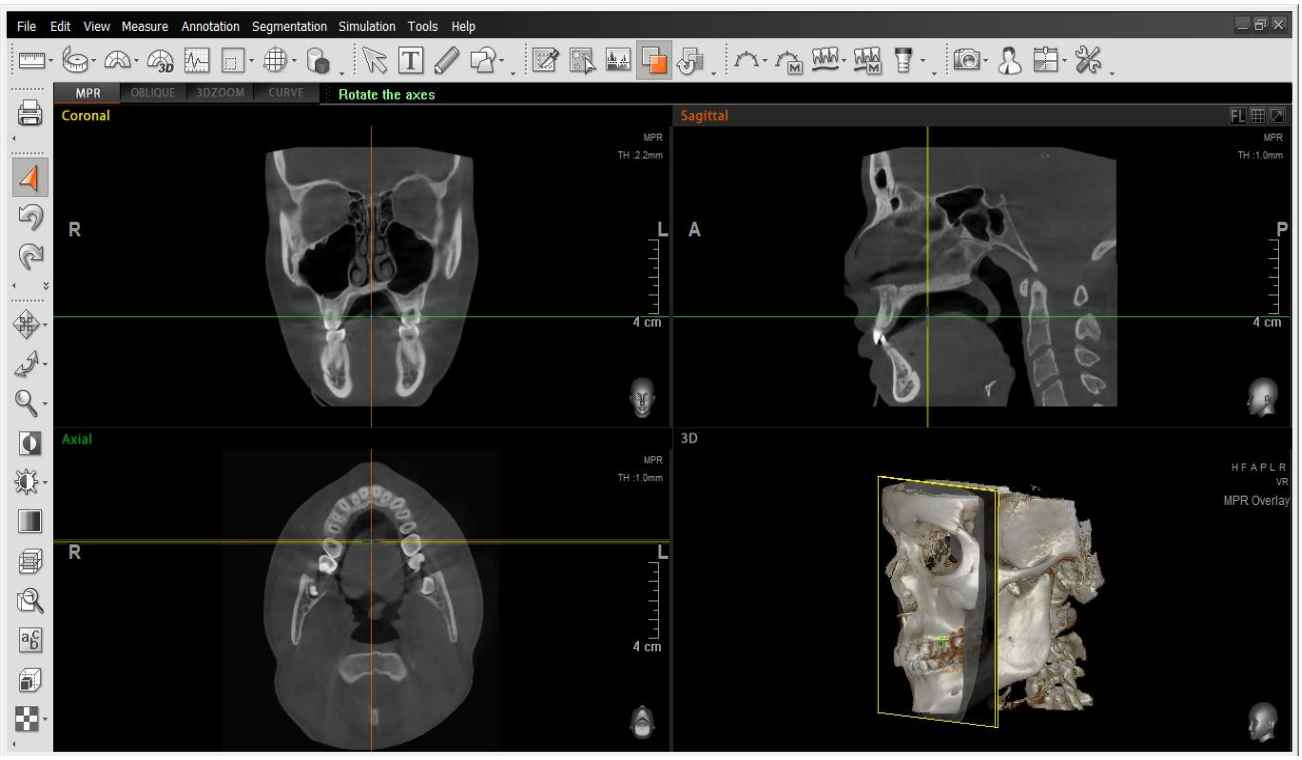
There is a known method of stratified research (Davydov B. N. *et al.*, 2021) with the study of cast models and CBCT. Researchers used CBCT scans of the jaws to measure the width of the apical base between the canines and first premolars. The technique involved assessing the relationship between the size of the apical base and the interincisal angle, intercanine width of the dentition and longitudinal length of the dentition [21].

The use of three-dimensional images makes it possible to fully assess the size and position of the apical bases, as well as the structures that form them, which will contribute to more complete and accurate planning of the orthodontic treatment.

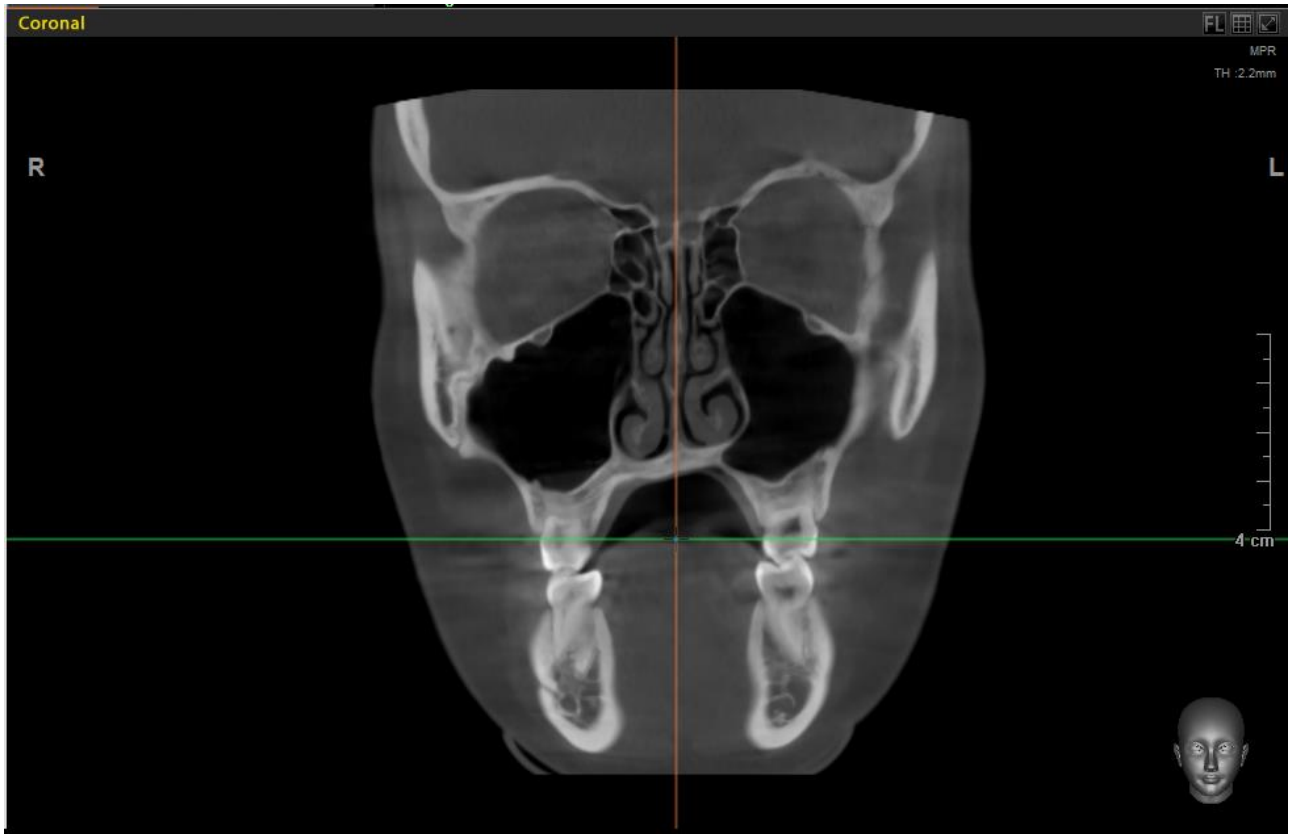
The purpose of the study is to develop a method for assessing the structural features and position of the apical bases of the jaws using CBCT.

Experimental Part, Analysis, Generalization and Explanation of Own Data

An analysis of 33 CBCT scans of the jaws of patients aged 18–44 years was carried out, which includes patients at a young age according to the classification of the World Health Organization, with the absence of dental anomalies. Cone beam computed tomography was performed with a scanning field (Field of View (FOV)) of 16*16 mm, voxel size 0.4 mm, X-ray radiation parameters 50–95 kV, 1-12 mA on a ProMax 3D device (Planmeca, Finland). The image capture area included the lower and upper jaws, alveolar ridges of the maxillary sinuses, nasal bones, orbits, and the temporomandibular joint. Tomographic data was obtained in the form of DICOM files, which were subsequently processed in the specialized program "Ez3D Plus". The jaws were assessed in the axial, coronal and sagittal planes in multiplanar mode. The layer thickness was changed depending on the tasks being solved from 0.125 mm to 10 mm. Measurements were performed on a coronal section in the area of premolars and molars (Fig. 1).



A.



B.

Fig. 1 Cone-beam computed tomography of the jaws with a scanning field of 16*16 mm. A – multi-planar mode, B – coronal section

RESULTS

A technique for measuring the apical bases of the jaws on CBCT has been proposed (patent registration No. 2024101213 dated January 18, 2024). There are 3 groups of parameters for analysis:

1. The width of the apical base of the jaw in various areas (6 parameters). Of these: a) Measurement along the outer contour of the jaws (3 parameters) b) Measurement along the internal contour of the jaw (3 parameters).
2. Half-width of the apical base of the jaws (2 parameters).
3. Measuring the inclination of the maxillary molars, alveolar processes and parts (4 parameters).

To implement the proposed method, following landmarks were used (Fig. 2):

Point J is on the outer (buccal) cortical plate of the alveolar process of the upper jaw in the area of the intersection of the tubercle of the upper jaw and the zygomatic buttress in the area of the molars on the right JR and on the left JL, as well as in the area of the premolars on the right JPR and on the left JPL.

Point P is on the internal (palatal) cortical plate of the alveolar process of the upper jaw in the area of transition of the palatal plate into the alveolar process of the upper jaw at the level of the first molars on the right P3R and on the left P3L, as well as at the level of the second premolars on the right P2R and on the left P2L.

Point R is on the outer (buccal) cortical plate of the alveolar part of the lower jaw in the area of the first molar at a distance of 8 mm from the cervical part of the tooth on the right RR and on the left RL, as well as on the inner (lingual) cortical plate on the right rR and on the left rL.

Point ZF is the intersection of the medial edge of the frontozygomatic suture with the orbit on the right ZFR and on the left ZFL.

Point M is the intersection of the perpendicular to the line JR and JL from the middle of the frontozygomatic line ZFR-ZFL.

Point M' is the intersection of the perpendicular to the line RR and RL from the middle of the frontozygomatic line ZFR-ZFL.

Point I is the intersection of the longitudinal axis passing through the bifurcation of the first molar of the maxilla with the JR-JL line on the right and left.

Point IP is the intersection of the longitudinal axis passing through the palatal roots of the first

maxillary molar with the JR-JL line on the right MIPA R and on the left MIPA L.

Point R is the point of intersection of the zygomatico-orbital line with the perpendicular passing through the middle of the apical width of the upper jaw on the right.

Point L is the point of intersection of the zygomatic-orbital line with the perpendicular passing through the middle of the apical width of the upper jaw on the left.

Point iR is the point of intersection of the zygomatic-orbital line with the perpendicular passing through the middle of the apical width of the lower jaw on the right.

Point iL is the point of intersection of the zygomatic-orbital line with the perpendicular passing through the middle of the apical width of the lower jaw on the left.

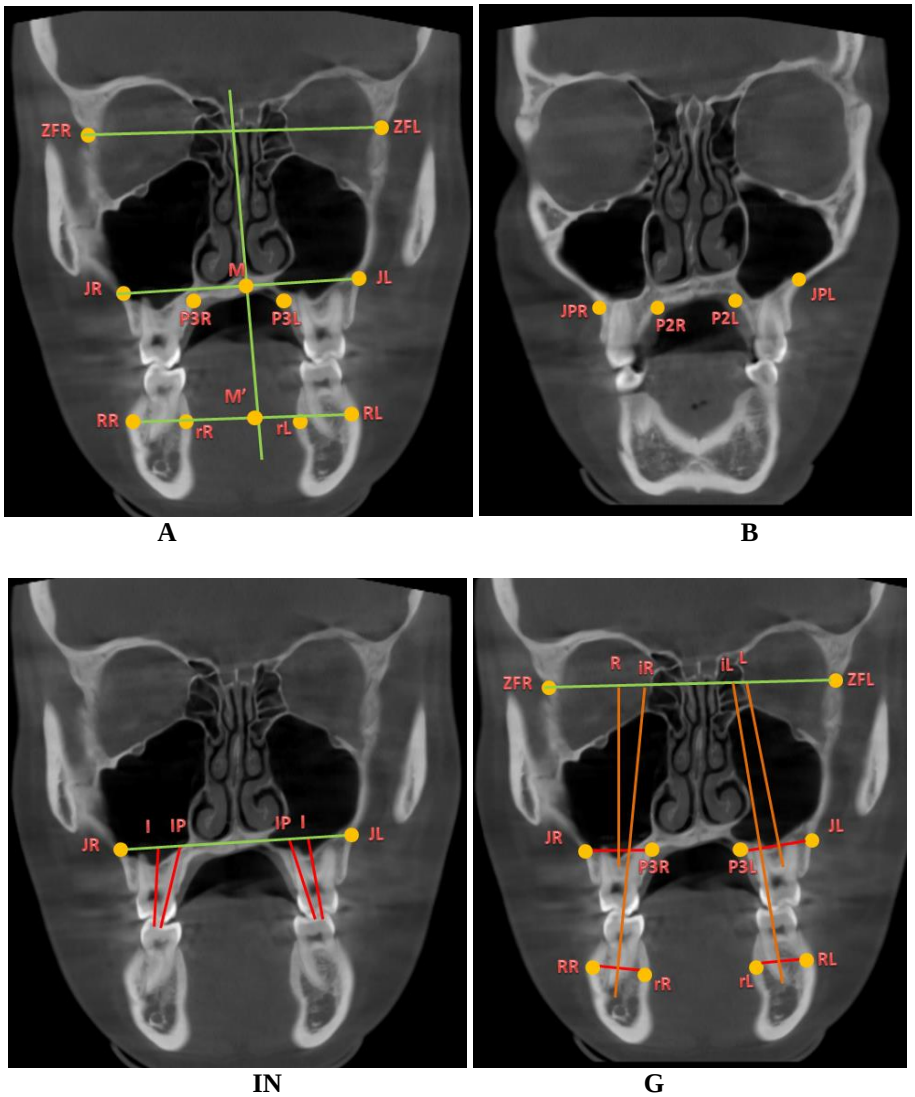
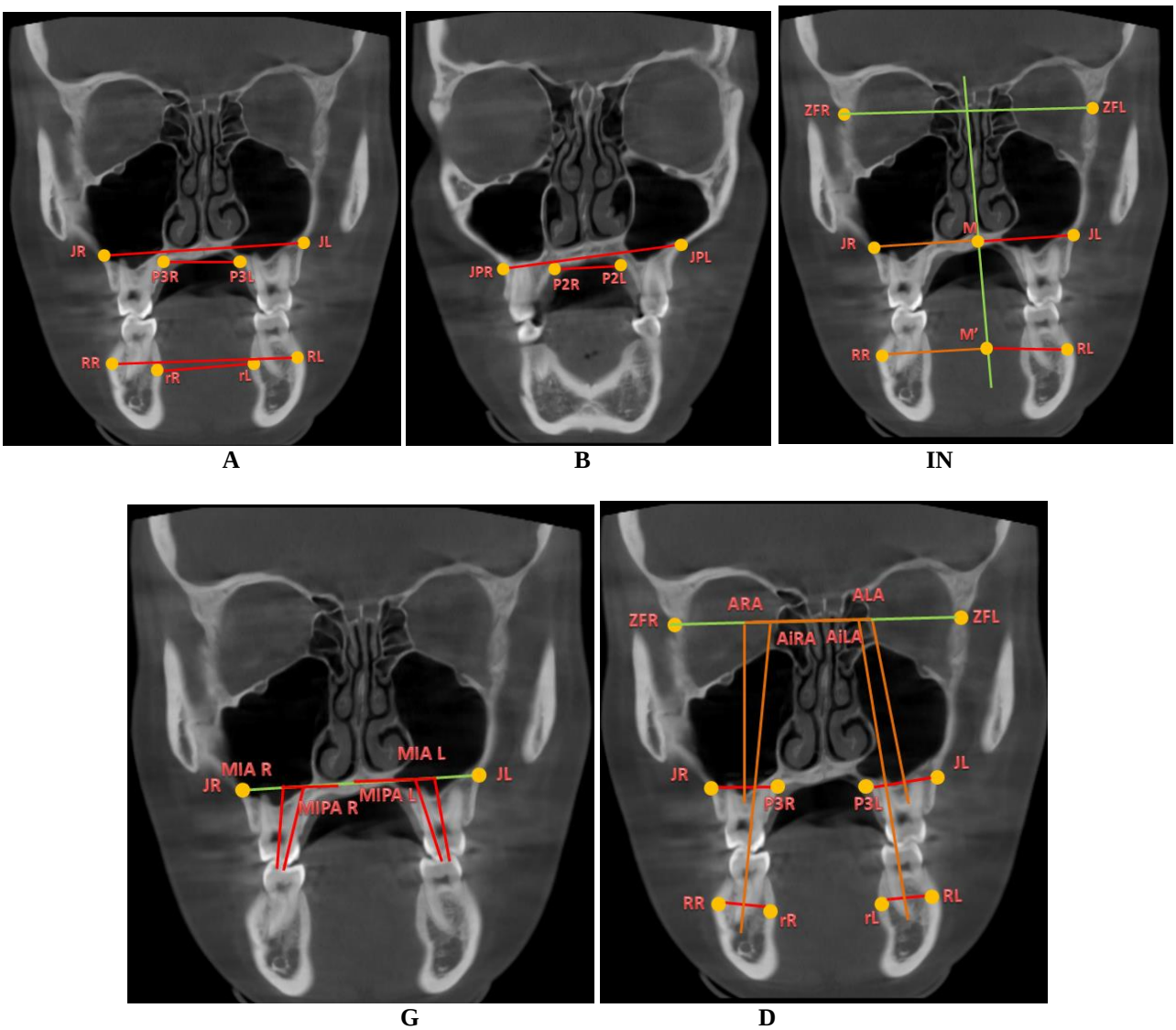


Fig.2: Points used in the research method A – points for determining the width and half-width of the apical bases in the area of the first molars; B – points for determining the width and half-width of the apical base of the upper jaw in the area of premolars; C – points for determining the angles of inclination of the first molars of the upper jaw; G – points for determining the angles of inclination of the alveolar parts of the jaws

The method for measuring the apical base of the jaws contains 12 parameters (Fig. 3):

1. External width of the apical base of the upper jaw in the area of the molars JR-JL;
2. Internal width of the apical base of the upper jaw in the area of the molars P3R-P3L;
3. External width of the apical base of the maxilla in the premolar region JPR-JPL;
4. Internal width of the apical base of the upper jaw in the area of the premolars P2R-P2L;
5. External width of the apical base of the lower jaw in the region of the molars RR-RL;

6. Internal width of the apical base of the lower jaw in the area of the molars rR-rL;
7. Half-width of the apical base of the upper jaw in the region of the molars on the right and left JR-M and JL-M;
8. Half-width of the apical base of the lower jaw in the region of the molars on the right and left RR-M' and RL-M';
9. Angle of inclination of the first molar of the upper jaw on the right and left MIA R and MIA L;
10. Angle of palatal inclination of the permanent maxillary molar on the right and left MIPA R and MIPA L;
11. Angle of inclination of the alveolar processes of the upper jaw relative to the zygomatic-orbital line on the right and left ARA and ALA;
12. Angle of inclination of the alveolar ridges of the lower jaw relative to the zygomatico-orbital line on the right and left AiRA and AiLA.



A **B** **IN**

G **D**

Fig. 3: Parameters of the method for studying the apical bases of the jaws. A – measurement of the external and internal width of the apical base of the upper and lower jaws in the area of the first molars; B – Measurement of the external and internal width of the apical base of the upper jaw in the area of the second premolars; C – Measurement of the half-width of the apical base of the upper and lower jaws in the area of the molars on the right and left; D – Measurement of the angle of inclination of the first molar of the upper jaw on the right and left and the angle of palatal inclination of the constant maxillary molar right and left; D – Measurement of the angle of inclination of the alveolar processes of the upper and lower jaws relative to the zygomatic-orbital line on the right and left

The average values of the proposed parameters in patients without dentofacial anomalies were determined (Table 1).

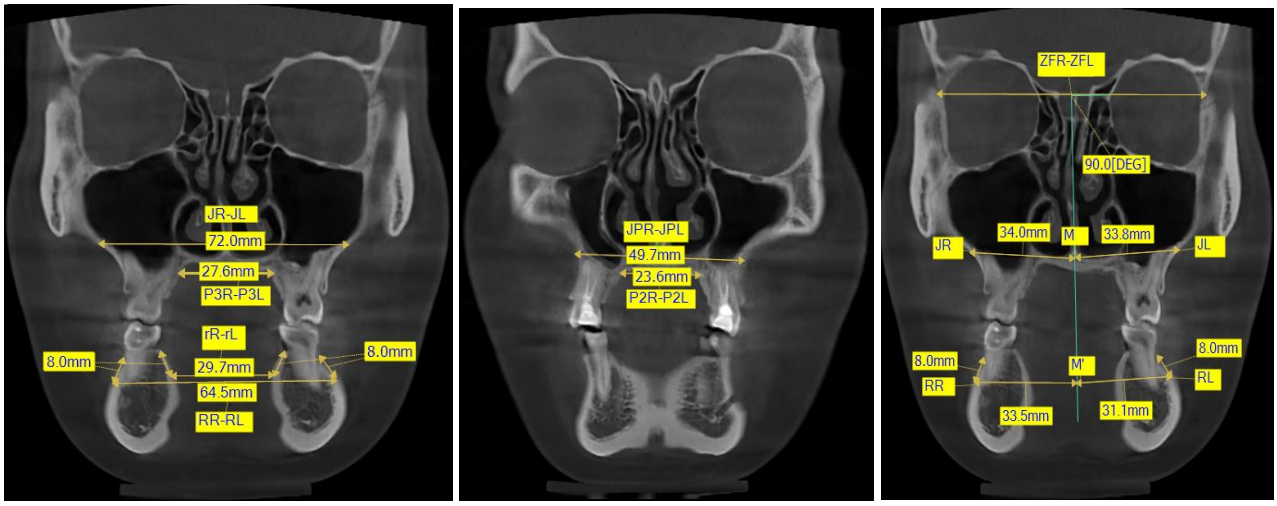
Table 1: Average values of the parameters of the apical basis of patients without dentofacial anomalies

Parameter	Definition	Norm	Arithmetic mean error	Standard Deviation
JJ	External width of the apical base of the upper jaw in the area of the molars	65.2 mm	±0.51	3.2
P3R-P3L	Internal width of the apical base of the maxilla in the molar area	31.5mm	±0.40	3.2
RR-RL	External width of the apical base of the lower jaw in the area of the molars	63.5mm	±0.26	1.5
rR-rL	Internal width of the apical base of the mandible in the area of the molars	33.4mm	±0.18	1.1
JPR-JPL	External width of the apical base of the upper jaw in the premolar region	45.4mm	±0.49	3.1
P2R-P2L	Internal width of the apical base of the maxilla in the premolar region	26.2mm	±0.31	1.9
JR-M JL-M	Half-width of the apical base of the upper jaw in the region of the molars on the right and left	32.1mm 31.6mm	±0.27 ±0.29	1.7 1.8
RR-M' RL-M'	Half-width of the apical base of the lower jaw in the region of the molars on the right and left	30.1mm 30.7mm	±0.75 ±0.25	4.6 1.6
MIA R MIA L	Angle of inclination of the first molar of the upper jaw on the right and left	98.55° 100.1°	±0.80 ±0.80	4.9 4.9
MIPA R MIPA L	Angle of palatal inclination of the permanent maxillary molar on the right and left	103.1° 103.8°	±0.38 ±0.46	2.3 2.8
ARA A.L.A.	Angle of inclination of the alveolar processes of the upper jaw relative to the zygomatico-orbital line on the right and left	99.5° 99.8°	±0.67 ±0.69	4.2 4.3
AIRA AILA	The angle of inclination of the alveolar ridges of the lower jaw relative to the zygomatic-orbital line on the right and left.	90.3° 91.3°	±0.34 ±0.49	2.1 3.1

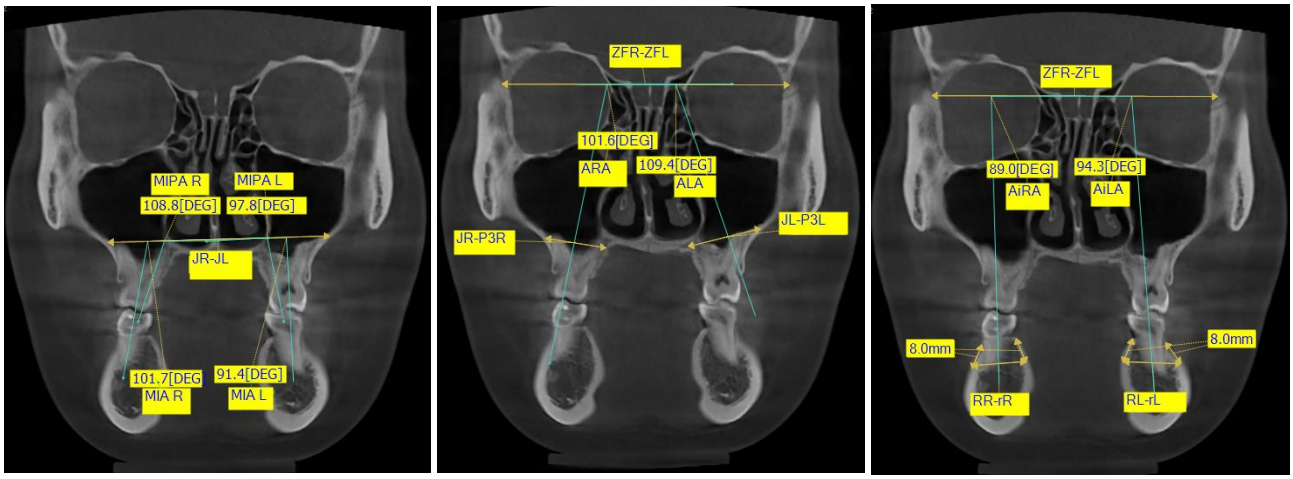
Clinical example

Patient A., 20 years old, was clinically diagnosed with distal occlusion, deep incisal occlusion, narrowing of the upper and lower dentition, protrusion of the incisors of the upper and lower jaws, crowded position of the teeth.

To plan orthodontic treatment, CBCT of the jaws was performed, on which 12 proposed parameters were studied (Fig. 4, Table 1).



A **B** **IN**



G **D** **E**

Rice. 4 Measurement of the apical basis of the subject A.A – Parameters JR-JL, P3R-P3L, RR-RL, rR-rL; B – Parameters JPR-JPL, P2R-P2L; C – Parameters JR-M, JL-M, RR- M', RL-M'; G – Parameters MIA R, MIA L, MIPA R, MIPA L; D – Parameters ARA, ALA; E – AiRA, AiLA parameters.

Table 1: Parameters of the apical basis for subject A.

Parameter	Definition	Patient A value.	Norm
JJ	External width of the apical base of the upper jaw in the area of the molars	72 mm	65.2±3.2 mm
P3R-P3L	Internal width of the apical base of the maxilla in the molar area	27.6 mm	31.5± 3.2 mm
RR-RL	External width of the apical base of the lower jaw in the area of the molars	64.5 mm	63.5± 1.5 mm
rR-rL	Internal width of the apical base of the mandible in the area of the molars	29.7 mm	33.4± 1.1 mm
JPR-JPL	External width of the apical base of the upper jaw in the premolar region	49.7 mm	45.4± 3.1 mm
P2R-P2L	Internal width of the apical base of the maxilla in the premolar region	23.6 mm	26.2± 1.9 mm
JR-M JL-M	Half-width of the apical base of the upper jaw in the region of the molars on the right and left	34 mm 33.8 mm	32.1± 1.7 mm 31.6± 1.8 mm
RR-M' RL-M'	Half-width of the apical base of the lower jaw in the region of the molars on the right and left	33.5 mm 31.1 mm	30.1± 4.6 mm 30.7± 1.6 mm
MIA R MIA L	Angle of inclination of the first molar of the upper jaw on the right and left	101.7° 91.4°	98.55± 4.9° 100.1°± 4.9°
MIPA R MIPA L	Angle of palatal inclination of the permanent maxillary molar on the right and left	108.8° 97.8°	103.1± 2.3° 103.8± 2.8°
ARA A.L.A.	Angle of inclination of the alveolar processes of the upper jaw relative to the zygomatico-orbital line on the right and left	101.6° 109.4°	99.5± 4.2° 99.8± 4.3°
AIRA AILA	The angle of inclination of the alveolar ridges of the lower jaw relative to the zygomatic-orbital line on the right and left.	89° 94.3°	90.3± 2.1° 91.3± 3.1°

The obtained measurements were compared with the norm. A narrowing of the internal width of the apical base of the upper jaw in the area of molars by 3.9 mm, a narrowing of the internal width of the apical base of the lower jaw in the area of molars by 3.7 mm, and a narrowing of the internal width of the apical base of the upper jaw in the area of premolars by 3.1 mm was revealed. The asymmetry of the apical bases was determined with an increase on the right in the upper jaw by 1.9 mm, and on the lower jaw by 3.4 mm. When analyzing the inclination angles, it was noted that the palatal inclination angle of the first molar of the upper jaw indicates an increase in torque on the right by 5. 7° and a reduction in torque on the left by 6°. The superior alveolar process on the left has a more buccal inclination of 9.6°. The data obtained should be used in drawing up an orthodontic treatment plan.

CONCLUSIONS AND RECOMMENDATIONS

The proposed method of research using cone-beam computed tomography of the jaws makes it possible to estimate the size and position of the apical bases of the jaws, which improves the methods for diagnosing dentofacial anomalies and makes the planning of orthodontic treatment more accurate.

This all points to the importance and continued interest in the study of the apical bases of the jaws. Modern dentistry is impossible without three-dimensional studies, which makes it possible to study the apical bases of the jaws from any angle and visualize the

most minor changes and parameters of the anatomical structures of the area under study. Using three-dimensional reformats from CBCT of the skull, it is possible to study in detail the parameters of the apical bases of the jaws in the sagittal, coronal and transversal planes with an accuracy of fractions of millimeters.

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