



Using the method of assessing the tongue position as an effective tool for diagnostic and increasing the stability of orthodontic treatment: A pilot study.

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ABSTRACT

Aim: The purpose of this research is in increasing the accuracy of determining the tongue position, the amount of space occupied by the tongue and space free from tongue, that information will help to increase of efficiency of diagnostics of dentofacial anomalies in patients, based on cone-beam computer tomography (CBCT) analysis conducted in transversal, sagittal and coronal planes.

Material and Methods: Clinical and x-ray examination and orthodontic treatment underwent in 65 patients with anomalies of the dentition complex. Patients divided into two groups. Group 1 - 25 patients aged 12 to 17 years. Group 2 - 40 patients aged 18 to 40 years. All patients underwent CBCT examination before, and during the retention period of treatment. Diagnostic examination carried out by the proposed method for diagnosing the anatomical and functional state of the dentition complex. After drawing up a treatment plan all patients underwent orthodontic treatment, which included the upper jaw expansion, using various orthodontic appliances. This method of CBCT diagnostic allows to identify anomalies in the position of the tongue before and after orthodontic treatment, to assess the quality of orthodontic treatment, based on the analysis of not only the tongue filling the space of the dome of the palate, but also the position of the bone structures of the skull in three planes.

Results: The study results showed that not all of the patients carried out recovery of the anatomical and functional balance of the maxillofacial complex after orthodontic treatment, suggesting the need for more myogymnastics and speech therapy training of the tongue before, during, and after treatment.

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Diagnostic of the tongue position, dentoalveolar complex anomalies, cone-beam computed tomography, cephalometric analysis, expansion of the upper jaw.

INTRODUCTION

The tongue position and function affects on the position of the teeth, shape and size of the dentoalveolar arches and on the bite formation. Not filling the

dome of the palate with tongue can cause the anatomical and functional disorders development in the dentofacial complex. Tongue dysfunction and

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the tongue position affects the development of surrounding bone and soft tissue structures. Violation of the positioning of the tongue in the oral cavity, contributes to the development of anomalies in the shape and size of the dentition, jaws, and violation of the functions of the dentition system. In addition, a violation of the positioning of the tongue is combined with a violation of its functions, as it reflects a violation of muscle balance. The tongue is a strong muscular organ and its effect on the surrounding organs and tissues plays an important role in their development. Clinical methods of research require clarification, as they do not always allow to identify anomalies in the size and position of the tongue. Therefore, it is absolutely necessary to know the position of the tongue in the oral cavity [1 - 11].

Thus, the diagnostic of the tongue position and function is relevant, and the creation of an informative method for assessing the balance in the dentofacial complex will improve the efficiency of diagnostic and treatment planning in daily orthodontic practice.

The purpose of this study is to increase the accuracy of determining the position of the tongue, the amount of space occupied by the tongue and the space free of the tongue, increasing the efficiency of diagnostic of dentofacial anomalies in patients, based on the analysis of a CBCT study conducted in the transverse and sagittal planes.

MATERIAL AND METHODS

This study was conducted on a two treatment groups of 65 patients (12 males, 43 females). 1st group - 25 patients (10 males, 15 females) aged 12 to 17 years old (mean age of 13,5 years old). 2nd group - 40 patients (18 males, 22 females) aged 18 up to 40 years old (mean age of 24,5 years old). All patients were treated with fixed palatal expander, 10 patients from the 2nd group were treated with bone-borne palatal expander. The inclusion criteria were the following: tongue dysfunction; skeletal posterior crossbite; patients with constriction and deformation of the upper jaw in transverse plane; adolescents; adult patients; Class III skeletal relationships (ANB -1), overjet 1 mm, unilateral Class III molar relationships half a cusp. The exclusion criteria were the following: patients affected by systemic diseases; bone pathology; tooth agenesis; poor hygiene; previous orthodontic treatments.

All patients underwent a CBCT scan before treatment, and in the retention period. To evaluate the effects of the treatment on subjects with tongue dysfunction, constriction and deformation of the upper jaw, crossbite malocclusion, a control group of patients treated with bracket-system without maxilla expansion was matched. The control group consisted of 50 treated patients (24 males, 26 females), (mean age of 19 years old). All patients gave

informed written consent and were evaluated and treated by the same orthodontist.

After drawing up a treatment plan all patients underwent orthodontic treatment, which included the upper jaw expansion using various orthodontic appliances. Patients were observed in dynamic, and in the retention period of treatment a similar control CBCT examination was performed and includes the proposed method for diagnosing of the lingual posture and the state of the anatomical and functional balance in the maxillofacial region.

All patients underwent a lingual physiotherapy during and after orthodontic treatment. After active orthodontic treatment patients were observed for three years in their retention period.

The measurement procedure was carried out as follows: not filling the dome of the palate with the tongue was evaluated on a CBCT performed in the natural head position in a rectangular coordinate system, located in the mid-sagittal plane, where the reference point coincided with the top of the posterior nasal spine (SpP), the abscissa axis determined the horizontal line, and the ordinate axis is vertical. The tongue position relative to the space of the maxillofacial region in the sagittal and frontal planes was evaluated. In the sagittal plane was determined by the distance (P1T1) mm, (P2T2) mm, (P3T3) mm, from points located on the mucosa of the palate (P1, P2, P3) from the top of the posterior nasal spine (SpP) at a distance of 10 mm (P1) , 20 mm (P2) and 30 mm (P3) located at the level of the middle palatine suture to the back of the tongue (Fig. 1).

At a distance of P1T1, P2T2, P3T3 equal to 0 - 2,5 mm, the anatomical and functional state of the dentofacial complex was normal (Fig. 5). If the distance P1T1, P2T2, P3T3 is more than 2,5 mm, the anatomical and functional state of the dentofacial complex is violated (Fig. 6). When the distance between them was 0 - 2,5 mm, the anatomical and functional state of the dentofacial complex was normal (Fig. 7). At a distance between points from the lateral surfaces of the tongue to the mucous membrane of the palate (TR1, TL1, TR2, TL2, TR3, TL3) at the level of perpendiculars drawn from the above points on the mucosa of the palate (P1, P2, P3) to the back of the tongue (T1, T2, T3) more than 2,5 mm the anatomical and functional state of the dentofacial complex was impaired (Fig. 8). The choice of these points was due to the fact that the thickness of the soft tissues of the palate in them is minimal.

Statistical analysis

All measurements were performed by the same calibrated examiner.

A statistical analysis of the research results was carried out. The degree values of filling the dome of the palate with the tongue before and after the treatment and the degree of expansion of the upper jaw

are presented in the tables. Descriptive statistics (means and standard deviations) of all continuous variables were evaluated (Tables 1 - 3). SPSS 21 software was used for statistical analysis. Data are expressed as means and standard deviations: $M \pm SD$. Comparisons were made by t Student's test. P value < 0.05 was considered statistically significant.

The non-filling of the dome of the palate with the tongue in the frontal plane was determined by the distance (TR1, TL1, TR2, TL2, TR3, TL3) from the lateral surfaces of the tongue to the palate mucosa at the level of perpendiculars drawn from the above points on the palate mucosa (P1, P2, P3) to the back of the tongue (T1, T2, T3) (Fig. 2-4).

RESULTS

After a diagnostic examination and drawing up a treatment plan, an appliance for RME was fixed. Activation of the device was carried out for a quarter of a turn for a month, then after 6 months of holding the achieved expansion, the device was removed. A dynamic observation of the patient was performed. two years after the initial diagnosis, a similar control examination was performed, including the proposed method for diagnosing the position of the tongue and the state of anatomical and functional balance in the maxillofacial region.

The given data correspondingly reflect the values of the studied parameters at the time of the diagnostic and control examination.

The results analysis in the tongue position and the anatomical and functional balance recovery in the dentofacial complex showed that in 63% of cases the tongue position was normalized, in 19% of cases the tongue position in the dome of the palate was improved up to 3 ± 0.5 mm, in 18% there was no improvement of the tongue position, which required the need for extra therapeutic measures for myogymnastics of the tongue, speech therapy training in the complex treatment of patients with dentoalveolar anomalies and functional disorders.

DISCUSSION

Assessment of the status of tongue in these groups of patients were selected to determine the relationship of the formation of the articulation of l tongue and its anatomical position during the formation stages of dentognathic complex and the influence of orthodontic treatment on the position and function of the tongue.

In the first group, aged 12 to 17 years, during the formation of a permanent bite and ossification of the bone structures of the maxillofacial region, we had the goal of restructuring the function of the tongue in the pubertal growth period. Orthodontic treatment consisted of expansion of the upper jaw in the first place to create the area necessary for the position of the tongue at rest and when swallowing.

According to the study data, the space measured on the sagittal plane - P1T1 space after treatment reached the norm and decreased by an average of 4.12 ± 4.14 mm, which corresponds to the position of the tongue root to the base of the hard palate, departing from the posterior nasal awn (SpP) at a distance of 10 mm. The P2T2 space after treatment reached the norm and decreased by an average of 4.90 ± 4.59 mm, which corresponds to the position of the back of the tongue to the hard palate. The P3T3 space after treatment decreased by half and reached a reduction in space by an average of 4.14 ± 7.91 mm, which corresponds to the position of the tip of the tongue towards the hard palate. This indicator indicates a possible instability of the position of the tip of the tongue during cone-beam computed tomography. The space measured on the frontal plane Tr1T1 after treatment reached normal and decreased by an average of 12.51 ± 8.83 mm, which corresponds to the position of the posterior third of the tongue at points on the lateral surfaces of the tongue at the level corresponding to the parameter P1T1 in the sagittal plane. The space measured on the frontal plane of Tr2T2 after treatment reached the norm and decreased by an average of 9.31 ± 5.47 mm, which corresponds to the position of the lateral surfaces of the tongue at the level corresponding to the parameter P2T2 in the sagittal plane. Space, as measured in frontal plane Tr3T3 after treatment reached normal and declined by an average of 7.69 ± 5.23 mm, which corresponds to lateral surfaces of the tip of the tongue points on the lateral surfaces of tongue at a level corresponding parameter P3T3 in the sagittal plane.

In the second group, aged 18 to 40 years, during the period of permanent occlusion and complete mineralization of the bone structures of the maxillofacial region, we had a goal in trying to make the function of the tongue normal. Orthodontic treatment consisted of the expansion of the upper jaw using fixed expanders with various types of fixation to achieve expansion at both the skeletal and dentoalveolar levels and to create the area necessary for the position of the tongue at rest and when swallowing. According to the study it is seen that the space P1T1 after treatment decreased on average by 5.85 ± 6.44 mm, which corresponds to the position of the root of the tongue to the base of the hard palate, away from the posterior nasal spine (SpP) at a distance of 10 mm. Space P2T2 after treatment decreased on average by 5.02 ± 5.62 mm, which corresponds to the position of the tongue to the hard palate. The P3T3 space after treatment decreased by half and reached a reduction in space by an average of 3.22 ± 4.34 mm, which corresponds to the position of the tip of the tongue towards the hard palate. These indicators indicate incomplete restoration of the anatomical and functional balance of the dental

complex. The space measured on the frontal plane Tr1T1 after treatment reached normal and decreased by an average of 17.51 ± 8.59 mm, which corresponds to the position of the posterior third of the tongue at points on the lateral surfaces of the tongue at the level corresponding to the parameter P1T1 in the sagittal plane. The space measured on the frontal plane of Tr2T2 after treatment reached the norm and decreased by an average of 7.31 ± 5.58 mm, which corresponds to the position of the lateral surfaces of the tongue at the level corresponding to the parameter P2T2 in the sagittal plane. Space, as measured in frontal plane Tr3T3 after treatment reached normal and decreased on average by 6.53 ± 5.23 mm, which corresponds to lateral surfaces of the tip of the tongue points on the lateral surfaces of tongue at a level corresponding parameter P3T3 in the sagittal plane.

In the control group, orthodontic treatment consisted of expanding the upper jaw using a fixed bracket system and cross-type elastics to create stable occlusion in transverse dimension. According to the study data, the P1T1 space after treatment decreased by an average of 2.68 ± 7.36 mm, which corresponds to the position of the root of the tongue to the base of the hard palate, retreating from the posterior nasal awn (SpP) at a distance of 10 mm. The P2T2 Space after treatment decreased by an average of 1.42 ± 6.43 mm, which corresponds to the position of the back of the tongue to the hard palate. The P3T3 space after treatment decreased by half and reached a reduction in space by an average of 1.31 ± 2.89 mm, which corresponds to the position of the tip of the tongue towards the hard palate. These indicators indicate incomplete restoration of the anatomical and functional balance of the dental complex. The space measured on the frontal plane Tr1T1 after treatment reached normal and decreased by an average of 17.51 ± 8.59 mm, which corresponds to the position of the posterior third of the tongue at points on the lateral surfaces of the tongue at the level corresponding to the parameter P1T1 in the sagittal plane. The space measured on the frontal plane for all three indicators decreased slightly and did not reveal statistically reliable indicators of the influence of orthodontic treatment on the position and function of the tongue.

Positive data on the results of complex treatment of patients indicate the possibility of the creation the normal position of the tongue and achieving anatomical and functional balance of the dental complex. The age of the patient plays an important role in achieving stable results, but when comparing the results of treatment of the control group of patients with a group of adult patients who underwent rapid palatal expansion, it can be noted that the position of the tongue was much better and closer to normal than in the control group. This indicates the need to create anatomical conditions for normal function.

This method allows quickly and accuracy identification of anomalies in the tongue position in patients with dentoalveolar anomalies before and after orthodontic treatment, aimed at the upper jaw expanding, tongue space increasing, the anatomical and functional balance changing in the maxillofacial region.

The advantages of the proposed method:

- high accuracy in assessing anatomy, the tongue position in space;
- the ability to analyze and evaluate anatomical structures (position of the upper and lower jaws, tooth inclinations, morphological features of the skull bones, airway clearance);
- the study does not require additional materials and devices;
- the speed of the technique, which is comfortable for the patient;

lack of need for cooperation with the patient. This method allows you to identify anomalies in the tongue position before and after orthodontic treatment, to assess the quality of the orthodontic treatment, based on an analysis of not only filling the space of the dome of the palate with the tongue, but also on the position of the bone structures of the skull in three planes. The high quality of the study allowed us to give a reliable assessment of the condition of the maxillofacial structures: the position of the upper and lower jaws, tooth inclinations, the stage of the patient's growth, airway clearance and the influence of the tongue on these structures at different stages of development of the maxillofacial part of the skull.

CONCLUSIONS

1. Diagnostic of the tongue position and articulation is extremely important to achieve stable results in orthodontic treatment.
2. Filling the dome of the palate with the tongue positively affects the anatomical and functional balance of the dentofacial complex.
3. When comparing the results of the study, not all patients after rationally conducted orthodontic treatment restored the anatomical and functional balance of the maxillofacial complex, which indicates the need for additional tongue myogymnastics before, during and after treatment.
4. The expansion of the upper jaw using various devices allows you to create the necessary volume to further achieve the anatomical and functional balance of the maxillofacial region.

DISCLOSURE OF INTEREST

the authors declare that they have no competing interest.

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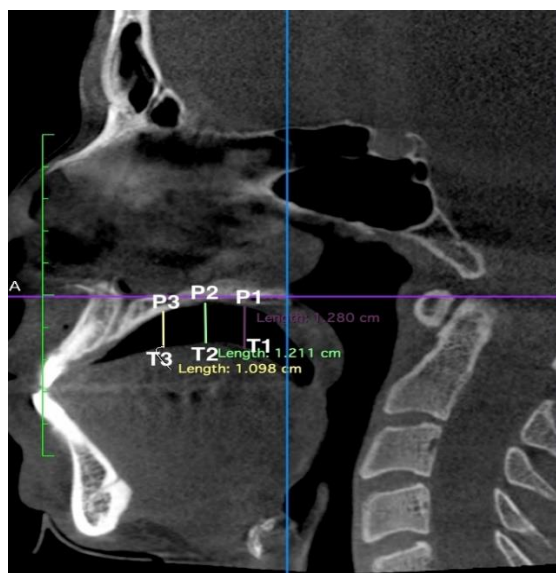


Fig. 1. P1T1, P2T2, P3T3 - distance from points located on the mucous membrane of the palate (P1, P2, P3) from the top of the posterior nasal spine (SpP) at a distance of 10 mm (P1), 20 mm (P2) and 30 mm (P3) located at the level of the middle palatine suture to the back of the tongue in the sagittal plane (T1, T2, T3).

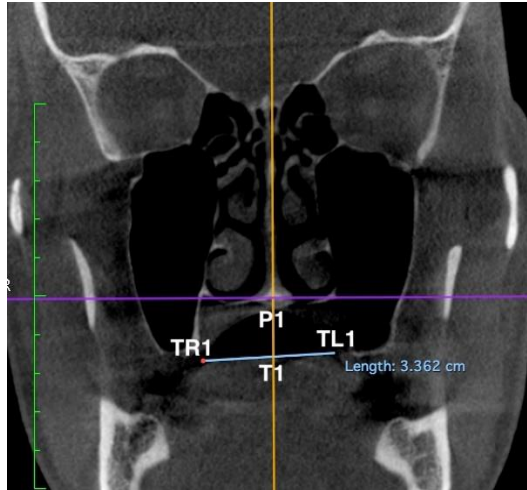


Fig. 2. TR1-TL1 - not filling the tongue of the dome of the palate in the frontal plane, measured from the lateral surfaces of the tongue to the mucosa of the palate at the level of the perpendicular drawn from the mucosa of the palate to the back of the tongue (P1T1).

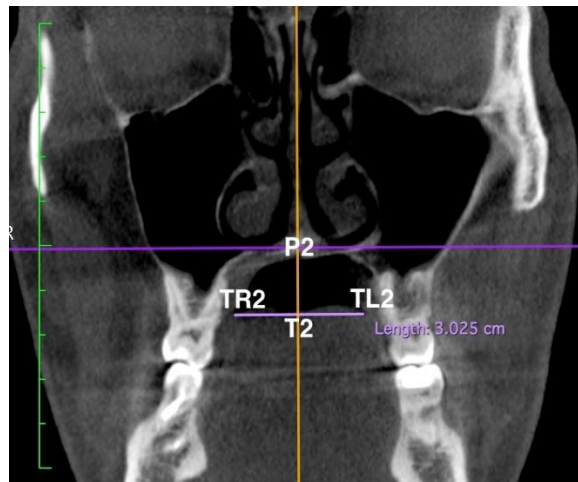


Fig. 3. TR2-TL2 - not filling the tongue of the dome of the palate in the frontal plane, measured from the lateral surfaces of the tongue to the mucosa of the palate at the level of the perpendicular drawn from the mucosa of the palate to the back of the tongue (P2T2).

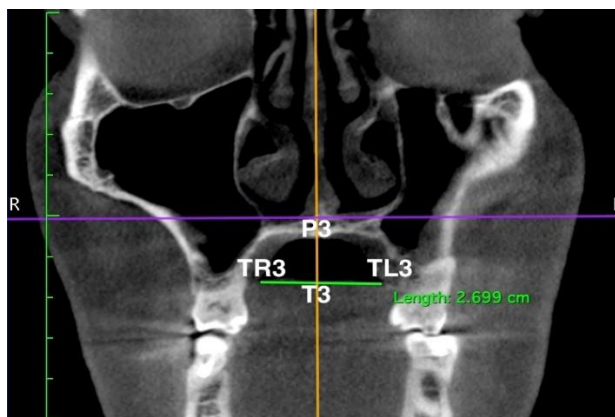


Fig. 4. TR3-TL3 - not filling the tongue of the dome of the palate in the frontal plane, measured from the lateral surfaces of the tongue to the mucous membrane of the palate at the perpendicular level, drawn from the mucosa of the palate to the back of the tongue (P3T3).

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Fig. 5. Sagittal plane - the tongue completely fills the dome of the palate - the anatomical and functional state of the dentofacial complex is normal.

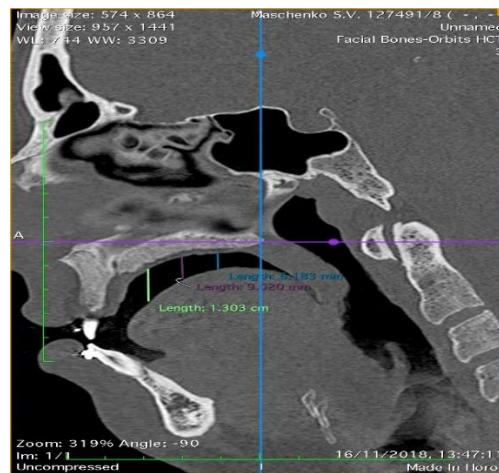


Fig. 6. Sagittal plane - not filling the dome of the palate with the tongue - distance P1T1, P2T2, P3T3 more than 2 mm - the anatomical and functional state of the dentofacial complex is impaired.



Fig. 7. The frontal plane - the tongue completely fills the dome of the palate - the anatomical and functional state of the dentofacial complex is normal.



Fig. 8. The frontal plane - not filling the palate dome with the tongue - the distance TR1-TL1 is more than 2 mm - the anatomical and functional state of the dentofacial complex is violated.

Table 1: Assessment of the degree of filling the dome of the palate with the tongue before and after treatment in the 1st group

Parameters, mm	Before Treatment		After Treatment		Decrease		P(T<=t) two-tail
	Average	Standard deviation (SD)	Average	Standard deviation (SD)	M	± SD	
P1T1	6,51	3,99	3,38	4,28	-3,12	± 4,13	0,0143
P2T2	7,45	4,92	3,55	4,25	-3,90	± 4,59	0,0073
P3T3	8,79	6,60	4,65	6,44	-4,14	± 6,52	0,0720

Table 2: Assessment of the degree of filling the dome of the palate with the tongue before and after treatment in the 2-d group

Parameters, mm	Before Treatment		After Treatment		Decrease		P(T<=t) two-tail
	Average	Standard deviation (SD)	Average	Standard deviation (SD)	M	± SD	
P1T1	5,54	3,69	2,68	4,42	-2,86	± 4,06	0,0002
P2T2	5,00	4,12	3,00	4,37	-2,00	± 4,24	0,0070
P3T3	4,32	4,30	2,07	4,13	-2,24	± 4,22	0,0013

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Table 3: Assessment of the degree of filling the dome of the palate with the tongue before and after treatment in the control group

Parameters, mm	Before Treatment		After Treatment		Decrease			P(T<=t) two-tail
	Average	Standard deviation (SD)	Average	Standard deviation (SD)	M	±	SD	
P1T1	6,78	2,02	5,70	3,00	-1,08	±	2,51	0,0380
P2T2	6,64	2,68	6,05	3,47	-0,59	±	3,08	0,1164
P3T3	6,49	2,59	5,09	2,80	-1,40	±	2,69	0,0798