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CHARACTERISTICS OF MAXILLOMANDIBULAR TRANSVERSAL DIMENSIONS IN DIFFERENT CLASSES OF MALOCCLUSION

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Insufficient width of the upper jaw can lead to the formation of a unilateral or bilateral crossbite or dental compensation. Measurement methods using cone-beam computed tomography became considered the most reliable.

The purpose of our article was to study the width of the upper and lower jaw using computed tomography scans in subjects with different Classes of malocclusion.

Materials and methods. The research group included 66 non-growing subjects aged from 15 to 25 years. Female persons were 50 (75.8%), male – 16 (24.2%). All subjects were divided into 3 groups according to ANB angle: skeletal Class I group had ANB angle between 0° and 4° (n = 26 (39.4%), skeletal Class II group had ANB angle >4° (n = 34 (51.5%), and skeletal Class III group had ANB angle <0° (n = 6 (9.1%). The width of the upper and lower jaw was analyzed according to University of Pennsylvania Cone-Beam CT Analysis (Penn method) and Yonsei Analysis on cone-beam computed tomography scans.

Results. In patients with the Class I the width of the upper jaw, measured by Penn method, slightly prevailed over the width of the lower jaw, but the difference was statistically insignificant ($p>0.05$). According to Yonsei method, maxilla transversal dimensions were slightly larger than mandibular width ($p>0.05$). In the Class II Group maxilla skeletal width was bigger than mandible width ($p<0.05$). The dental width did not differ significantly ($p>0.05$), indicating a compensatory lingual inclination of upper posterior teeth, and upright position of lower molars. In the Class III Group mandible transversal dimensions both in the area of the basal bone and in the area of teeth rotation center was bigger ($p<0.05$). The maxillomandibular width difference between dental points were less than between basal, which may indicate a compensatory lingual inclination of the lower posterior teeth.

Conclusion. Comparison of the maxillomandibular difference, measured by basal and dental points, indicates dental compensation in the Class II – lingual inclination of posterior upper teeth, in Class III – lingual inclination of posterior lower teeth.

Keywords: maxillofacial region, malocclusion, transverse anomalies, dental arch width, computed tomography.

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ХАРАКТЕРИСТИКА ТРАНСВЕРЗАЛЬНИХ РОЗМІРІВ ЩЕЛЕП ПРИ РІЗНИХ КЛАСАХ ПАТОЛОГІЇ ПРИКУСУ
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Описані зміни трансверзальних розмірів верхньої та нижньої щелепи залежно від класу аномалій прикусу за Angle. Групу дослідження становили 66 пацієнтів віком від 15 до 25 років. Осіб жіночої статі було 50 (75,8%), чоловічої – 16 (24,2%). Обстежених розділено на 3 групи залежно від скелетного класу аномалій прикусу за Angle: з I класом – 26 (39,4%) осіб, II класом – 34 (51,5%), III класом – 6 (9,1%) осіб. Всім пацієнтам на зрізах комп'ютерної томограми лицьового відділу скелету визначені трансверзальні розміри верхньої та нижньої щелепи за методами Yonsei та Pen. При першому класі базальна і дентальна ширина верхньої та нижньої щелепи відрізнялися одна від одної незначно. При третьому класі базальна ширина нижньої щелепи була статистично більшою за верхню, тоді як зубні параметри відрізнялися незначною мірою, що призводить до зубної компенсації. У пацієнтів із другим класом спостерігали збільшення розмірів верхньої щелепи порівняно з нижньою.

Ключові слова: зубощелепна система, прикус, трансверзальні аномалії, ширина зубного ряду, комп'ютерна томографія.

Introduction

The task of modern orthodontics is to create an optimally balanced occlusion, both in terms of aesthetic and functional characteristics, in harmony with the entire organism [1; 2]. To assess occlusal ratios at the beginning and, especially, at the end of orthodontic treatment, occlusion keys are widely used [2; 3]. However, without harmonious skeletal proportions, it is impossible to achieve the correct proportions of the teeth in three planes [1; 3; 4]. Regardless much focus of orthodontic diagnostics on the sagittal and vertical relationship, a proper evaluation of the transverse discrepancy has equal importance [5; 6]. For accessing occlusal balance in each individual case, it is extremely important to determine and correct the maxillomandibular transverse dimension [7]. Transversal inconsistency of the dental arches can cause anomalies in other planes. Exactly because of that, according to the opinion of some authors,

transversal malocclusion should be corrected as early as possible at the beginning of orthodontic treatment [3; 4; 8].

The most widely used method of measurement of transversal discrepancies is University of Pennsylvania CBCT Analysis (Penn), which is based on Ricketts' posteroanterior (P-A) analysis and Andrews' Element III Analysis. According to Penn Analysis, difference for the maxillary and mandible width in mature patients with normal occlusion is 5 mm [3].

The most common transverse problem is insufficient width of the upper jaw, which in turn can lead to the formation of a unilateral or bilateral crossbite or dental compensation in the form of excessive inclination of the lateral teeth of the upper and lower jaws. This compensation typically involves lingual tipping of the mandibular posterior teeth, and excessively tipped buccaly of upper posterior teeth. Such dental compensation of transverse discrepancies of the jaws leads to excursive posterior interferences. Narrowing of the upper jaw and excessively positively inclined posterior teeth lead to reduced buccal alveolar bone, thinning gingival tissues and the increased risk of gingival recession [1; 5].

For a long time, the methods of biometric measurement and analysis of dental arch were used in clinical practice. However, due to the presence of dental compensation, these methods are not completely objective, because they do not reflect exactly the skeletal width of the jaws and, accordingly, the ratio of the upper and lower jaw width and skeletal inconsistency [9–11]. With the development of modern technologies and the X-ray method of research, measurement methods using cone-beam computed tomography (CBCT) became considered the most reliable. Due to technical progress and the wide implementation of computer tomography in the practice of an orthodontist, scientists were engaged in the search for the most optimal points and methods of measuring the transverse dimensions of the jaws on computer tomography sections [12]. The one of the main tasks for accurate measurement was defining the normal ratio of the width of the lower and upper jaws [13; 14]. This has contributed to the development of new methods of measurement and their implementation in the practical work of the orthodontist. The most reliable methods of assessing transversal discrepancies are measurements between points on teeth crowns and alveolar processes of the jaws, which makes it possible to analyze dental compensation [11]. The question of the transverse ratio in different malocclusion Classes by Angle is also of great interest. This can provide an answer to the etiology of malocclusion in other planes and is important for a treatment plan [15; 16].

The purpose of our research was to study the width of the upper and lower jaw using CBCT scans in subjects with different Classes of malocclusion.

Materials and methods

The research group included 66 subjects who applied for orthodontic care. All patients were non-growing, aged from 15 to 25 years with permanent bite. An average age was 20.8±2.3 years. Female participants were 50 (75.8%), male was 16 (24.2%). Exclusion criteria for the research group were active orthodontic treatment or orthodontic treatment in the anamnesis, injuries, congenital malformations of the maxillofacial region, defects of the dental arch in the lateral areas. The studies were approved by the Commission on Ethical Issues and Biomedical Ethics of the Poltava State Medical University (protocol № 233 of December 24, 2024) and were conducted with the written consent of the participants and in accordance with the principles of bioethics set out in the Declaration of Helsinki "Ethical Principles of Medical Research Involving Humans" and the "Universal Declaration on Bioethics and Human Rights (UNESCO)".

All examined subjects were divided into 3 groups according to ANB angle: skeletal Class I group had ANB angle between 0° and 4° (n = 26 (39.4%), skeletal Class II group had ANB angle >4° (n = 34 (51.5%), and skeletal Class III group had ANB angle <0° (n = 6 (9.1%). A crossbite was determined in 7 subjects, which was combined in 2 (3.0%) cases with a mesial, in 5 (7.6%) – with a neutral ratio in the sagittal plane. All patients were performed CBCT of bones of the facial skeleton on the Gendex tomograph (Italy). 3DViewerRun software was used to analyze a cone-beam CT image at the multiplanar view (MPV) after properly orienting the image. The width of the upper and lower jaw was analyzed according to University of Pennsylvania Cone-Beam CT Analysis (Penn method) and Yonsei Analysis [1; 9; 14]. According to Penn method, the mandible width was measured from the intersection of the line that passes through the coronal cross-section of the first molars at the level of the furcation with the most buccal portion of the cortical plate at the axial plane on both the right and left sides. Figure 1 presents cone-beam CT sections for measuring the width of the lower jaw at Ricketts points using the Penn method.

The maxilla width is measured in position Mx-Mx (the transition of the alveolar process into the base of the jaw in the furcation center of the first molars) at the axial and coronal cuts of CBCT scans. Figure 2 shows an example of measurement of maxillary axial and coronal cuts.

Based on the data of Ricketts and Andrews, the optimal transverse difference between the maxilla and mandible is 5 mm in non-growing patients with permanent bite. Therefore, the ideal difference for the width of the jaws using the Penn CBCT analysis is also 5 mm.

According to Yonsei transverse analysis, the jaw width is measured between center of resistance (CR) points, located at the middle of the root furcation of the first permanent molars. Positions of the estimated CR points were pinpointed on different cutting slices in 3 planes of space: the axial, sagittal, and coronal sections (Figure 3). The width of the upper and lower jaws should be the same at the CR points. According to Yonsei Transverse Index, if the difference between maxillary and mandibular width was less than 2.26 mm, the patient was diagnosed with maxillary transverse deficiency (MTD).

The average value, the average error of the maxillary, mandible width, transverse discrepancy, if it was present, were calculated in each subgroup, according to the class of malocclusion by Angle. The data of patients with Class II and III were compared with the data of patients with Class I. The obtained data was statistically analyzed using Fisher's criterion at the level of significance $p<0.05$.

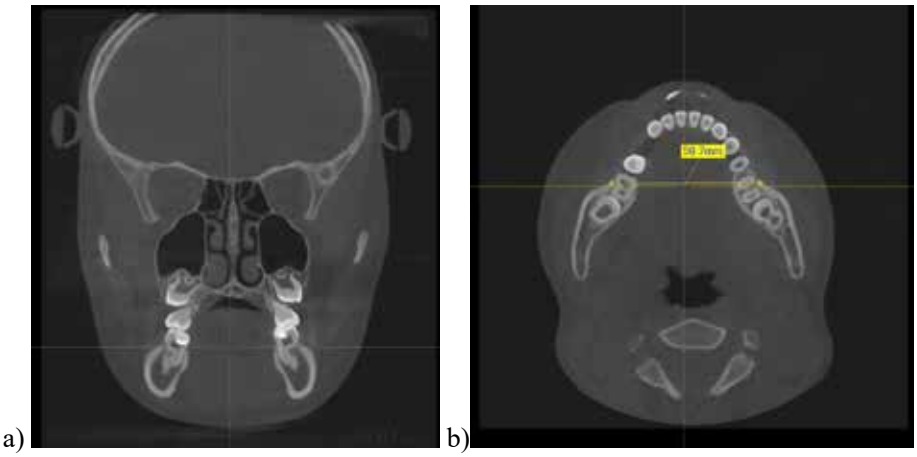

Fig. 1. Penn CBCT Transverse Analysis of a mandibular skeletal width: a) coronal cut through the mandibular first molars at the level of the furcation; b) measure on the axial slice where the coronal cut intersects the cortical bone, mandible width 59.7 mm

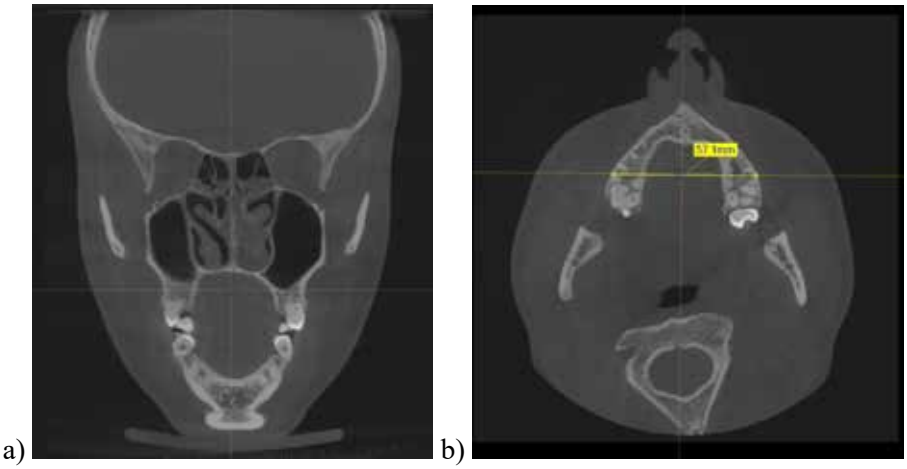

Fig. 2. Penn CBCT Transverse Analysis of a maxillary skeletal width: a) coronal cut through the Mx-Mx points; b) measure on the axial slice where the coronal cut intersects the cortical bone, maxillary width 57.1 mm

Results

The Table 1 summarizes the transverse measurements of upper and lower jaws in patients with different classes of malocclusion by Angle.

In patients with the Class I of malocclusion, the width of the upper jaw, measured by Penn method, slightly prevailed over the width of the lower jaw. The difference in the transverse dimensions of both jaws was statistically insignificant ($p>0.05$), that do not correspond to the normal value. According to Yonsei method, maxilla transversal dimensions were slightly larger than mandibular width, but did not differ significant ($p>0.05$). In the Class II malocclusion Group maxilla skeletal width differed significantly from mandible width and was bigger ($p<0.05$). However, the dental width between CR points did not differ significantly ($p>0.05$), indicating a compensatory lingual inclination of the upper posterior teeth, and a more upright position of the lower molars. In the Class III malocclusion

Fig. 3. Yonsei transverse analysis. (A–C) The location of the center of resistance (CR) points of the maxillary molar on the a) coronal, b) sagittal, c) axial sections

Table 1

The transverse measurements of upper and lower jaws by Penn and Yonsei Analysis in patients with different Classes of malocclusion by Angle

Variable	Penn Analysis			p_1	p_3	Yonsei Analysis			p_2	p_4
	Class I	Class II	Class III			Class I	Class II	Class III		
Maxilla measurement, mm	55.1±3.02	56.1±3.41	53.9±3.15	<0.05	>0.05	42.1±2.23	44.7±2.78	43.4±2.41	<0.05	>0.05
Mandible measurement, mm	54.3±3.37	52.7±3.48	58.7±3.84	<0.05	<0.05	41.4±2.16	43.2±2.23	46.6±2.72	<0.05	<0.05
p	>0.05	<0.05	<0.05			>0.05	>0.05	<0.05		

p_1 – the level of significance of measurements by Penn method between groups of subjects with the Class I and Class II malocclusion;

p_2 – the level of significance of measurements by Yonsei method between groups of subjects with the Class I and Class II malocclusion;

p_3 – the level of significance of measurements by Penn method between groups of subjects with the Class I and Class III malocclusion;

p_4 – the level of significance of measurements by Yonsei method between groups of subjects with the Class I and Class III malocclusion.

Group maxilla width differed significantly from mandible width ($p<0.05$). Mandible transversal dimensions both in the area of the basal bone and in the area of teeth rotation center was bigger. The maxillomandibular width difference between dental points were less than between basal, which may indicate a compensatory lingual inclination of the lower posterior teeth.

The width of the upper jaw in patients with the Class II of malocclusion was bigger compared to patients with the first Class according to Penn ($p_1>0.05$) and Yonsei ($p_2>0.05$) measures methods. Mandible width did not differ significant ($p_1>0.05$, $p_2>0.05$) in the Class II and Class I malocclusion subjects regardless of the measurement method.

Comparing the transversal dimensions of upper jaw in patients with Class I and Class III malocclusion, we found no significant difference ($p_3>0.05$, $p_4>0.05$). Between these two groups of patients, a significant difference was noted in the width of the lower jaw, both at the level of the teeth, measured by Yonsei method and at the level of the basal bone, determined by Penn method ($p_3<0.05$, $p_4<0.05$).

Discussion

Our study included patients with various malocclusion in the sagittal plane: Classes I, II, III. In our study, the difference in the transverse dimensions of the upper and lower jaw in patients with the Class I was 0.8±0.29 mm and was significantly different from the normal value. This may be one of the main causes of crowding. There was 2.6±0.07 mm of transversal difference in Class II Group, but it was also insufficient. In patients with Class III malocclusion, there were significant differences in the transversal dimensions of the jaws, and the lower jaw was significantly wider than the upper.

In patients with the first Class, the width of the upper jaw according to the Yonsei method is slightly larger than the width of the lower one, which corresponds to the norm.

In some studies, the maxillomandibular relationship was evaluated in anterior and posterior segments by distance between the center of resistance of canines, premolars and molars [13]. However, the main attention was paid to patients with III Class malocclusion, because transverse discrepancies is most pronounced clinically in such subjects. In between-group comparison, the skeletal Class III group showed significantly greater arch form in the mandible [14–16], which coincided with the data of our study. The widths of the mandibular basal bone were significantly larger than those of skeletal Class I and II [13; 16]. The maxillomandibular width difference of basal bone of skeletal Class III were significantly less than that of skeletal Class I and II [16; 17], which does not fully coincide with the data obtained in our study. The maxillary dental arch widths were significantly larger those of skeletal Class II [16]. In our studies, the width of the upper dental arch according to the Penn method was slightly greater among patients with Class II, but no significant difference was found. We did not observe a significant difference in maxillary basal width by Yonsei method between classes of malocclusion. It should be noted, that it is important to make comparisons not only between Classes groups, but also to evaluate the maxillomandibular difference within the group [17]. Compared maxilla width by Yonsei with measurements of the basal width by Penn method in patients with the Class I and Class II, the Class I and Class III may indicate dental compensation due to molar inclination. Many authors talk about the problem of dental compensation as one that hides a true transversal deficiency.

Conclusions

1. For orthodontic diagnosis of malocclusion, it is necessary to assess the transverse discrepancy not only at the dental but also at the skeletal level. To assess dental compensation, it is important to compare skeletal and dental maxillomandibular difference.

2. In patients with the Class I of malocclusion, the difference in the transverse dimensions of both jaws was statistically insignificant. In the Class III Group, the basal and dental width of the lower jaw was significantly greater than the upper. In patients with Class II malocclusion an increase in the width of the upper jaw was noted compared to the lower.

3. Comparison of the maxillomandibular difference indicates dental compensation, most pronounced in the Class II and III malocclusion. In subjects with III Class lingual inclination of posterior lower teeth was determined, in Class II subjects – lingual inclination of posterior upper teeth.

BIBLIOGRAPHY

1. Tamburrino RK. Objective criteria for phase I maxillary expansion. *J Clin Orthod*. 2024 Apr; 58(4): 236–242. PMID: 38754440.
2. Smaglyuk LV, Smaglyuk VI, Liakhovska AV, Trofymenko MV. EMG-activity of muscles of the cranio-mandibular system during functions of the dento-facial region. *The World of Medicine and Biology.* 2020; 1(71): 128–132. doi: 10.31718/mep.2024.28.1.04.
3. Tamburrino RK, Boucher NS, Vanarsdall RL, Secchi A. The transverse dimension: Diagnosis and relevance to functional occlusion. *RWISO J*. 2010; 2: 13–22. Available from: https://www.learncco.com/wp-content/uploads/2022/02/Transverse-Dimension.-Diagnosis-and-Relevance-to-Functional-Occlusion-Tamburrino-et-all.pdf.
4. Watted N, Lone IM, Midlej K. et al. The Complexity of Skeletal Transverse Dimension: From Diagnosis, Management, and Treatment Strategies to the Application of Collaborative Cross (CC) Mouse Model. *J Funct Morphol Kinesiol.* 2024 Mar 14; 9(1): 51. doi: 10.3390/jfmk9010051.
5. Zhang C, Guo Q, Liu W, Tang Y, Yuan R. Maxillary transverse deficiency diagnosed by 3 methods and its relationship with molar angulation in patients with skeletal Class III malocclusion. *Am J Orthod Dentofacial Orthop.* 2023 Jul; 164(1): 5–13. doi: 10.1016/j.ajodo.2022.09.015.
6. Koo YJ, Choi SH, Keum BT et al. Maxillomandibular arch width differences at estimated centers of resistance: Comparison between normal occlusion and skeletal Class III malocclusion. *Korean J Orthod.* 2017 May; 47(3): 167–175. doi: 10.4041/kjod.2017.47.3.167.
7. Dmytrenko MI, Smaglyuk LV, Gurzhiy OV, Liakhovska AV. Scientific achievements of Ukrainian scientist in diagnostics of temporomandibular joint diseases (literature review). *Wiad Lek.* 2023; 76(2): 427–432. doi: 10.36740/WLek202302126.
8. Coloccia G, Inchingolo AD, Inchingolo AM. et al. Effectiveness of dental and maxillary transverse changes in tooth-borne, bone-borne, and hybrid palatal expansion through cone-beam tomography: a systematic review of the literature. *Medicina (Kaunas).* 2021 Mar 19; 57(3): 288. doi: 10.3390/medicina57030288.
9. Dai J, Guo X, Zhang H. et al. Cone-beam CT landmark detection for measuring basal bone width: a retrospective validation study. *BMC Oral Health*. 2024 Sep 14; 24(1): 1091. doi: 10.1186/s12903-024-04798-2.
10. Chen YW, He H. Advances in diagnostic methods of maxillary transverse deficiency. *Zhonghua Kou Qiang Yi Xue Za Zhi.* 2021 Jan 9; 56(1): 104–108. (In Chinese). doi: 10.3760/cma.j.cn112144-20200526-00297.
11. Zhang H, Guo D, Ma Y. et al. Comparison between basal arch width in normal occlusions and class II malocclusions by using cone-beam computed tomography. *Heliyon.* 2024 Mar 15; 10(6): e28267. PMCID: PMC10965823, doi: 10.1016/j.heliyon.2024.e28267.
12. Vyzhenko Y, Kuroiedova V, Vyzhenko H, Makarova O, Stasiuk O, Halych L. The relationship between malocclusion and craniofacial profile pathology. *Eastern Ukrainian Medical Journal.* 2025; 13(1): 274–284. doi: https://doi.org/10.21272/eumj.2025;13(1):274-284.
13. Moon HW, Nam W, Ahn HW, Oh SH, Kook YA, Kim SH. Development of a maxillomandibular arch form based on the center of resistance of teeth using cone-beam computed tomography. *Am J Orthod Dentofacial Orthop.* 2022 Feb; 161(2): 208–219. doi: 10.1016/j.ajodo.2020.07.041.
14. Shmyndiuk M, Gevkaliuk N, Pynda M, Dovbenko S, Smaglyuk L. Evidences from systematic reviews regarding miniscrew-assisted rapid palatal expansion (MARPE) approach in orthodontics. *Ukrainian Dental Journal*. 2023; 2(2): 131–137. doi: 10.56569/UDJ.2.2.2023.131-137.
15. Yu ZH, Duan YG, Cui YT, Tian YL. Transverse characteristics of normodivergent patients in different sagittal skeletal patterns. *Shanghai Kou Qiang Yi Xue.* 2024 Jun; 33(3): 312–317. doi: 10.19439/j.sjos.2024.03.018.
16. Ma T, Wang YH, Zhang CX, Liu DX. A novel maxillary transverse deficiency diagnostic method based on ideal teeth position. *BMC Oral Health.* 2023 Feb 7; 23(1): 82. doi: 10.1186/s12903-023-02790-w.
17. Lombardo L, Setti S, Molinari C, Siciliani G. Intra-arch widths: a meta-analysis. *Int Orthod*. 2013 Jun; 11(2): 177–92. (In English, French). doi: 10.1016/j.ortho.2013.02.005.
18. Pavlenko SA, Pavlenkova EV, Tkachenko IM, Sidorova AI, Korol DM. Prognostic indices of pathological tooth wear development. *Wiad Lek.* 2020; 73(7): 1345–1349. doi: 10.36740/WLek202007107.

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