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ORIGINAL ARTICLE

Application of additional anthropometric and functional methods in children undergoing orthodontic treatment using braces

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Abstract *Background:* Occlusal interference causes instability in temporomandibular joint and hyperactivity of mastication muscles which eventually leads to temporomandibular joint dysfunction. Therefore, achieving stable occlusion is important in young patients. It is key factor in optimizing functional occlusion in adulthood.

Aim: Application of «The ABO Model Grading System» and Mandibular Position Indicator as an additional diagnostic method in children undergoing orthodontic treatment using braces.

Methods: Thirty-two patients aged 14 to 18 diagnosed with teeth crowding on the upper and lower jaws were examined, then separated in two groups of 16 people each. All patients underwent orthodontic treatment using braces.

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Results: In group 2, due to application the anthropometrical system of quantitative evaluation ABO with re-fixing the incorrectly arranged braces by indirect bonding method, occlusal interferences were eliminated. MPI analysis showed discrepancy between the central occlusion and the central relation which was not as relevant as in the group 1 ($p > 0.05$).

Conclusion: Using the anthropometric system of quantitative assessment of ABO with subsequent re-fixation of incorrectly placed braces by indirect bonding, effectively improves the MPI. This determines the unity of position between articular condyles on the lower jaw in the centric occlusion and in the centric relation, which allows to get a stable result of orthodontic treatment.

1. Introduction

Orofacial area is a complex of various anatomical structures, such as temporomandibular joint (TMJ), maxilla and mandible, muscles of mastication and dental arches (Bordoni and Varacallo, 2019) which are responsible for speech, swallowing, breathing as well as carrying out facial expressions (Crane et al., 2013, Miyaoka et al., 2014, Pal et al., 2017, Bordoni and Varacallo, 2019).

When condyle is situated within the glenoid fossa in both TMJ in centric occlusion (CO) there is a balance in those structures. The mandibular position and occlusal relationship depends on the TMJ structures and muscles involved, deviations in alignment of CO and CR may cause pathology in either TMJ or teeth (Caldas et al., 2016).

Okeson (2015) identified CR as a stable position of the mandible in a correct orthopedic and musculoskeletal equilibrium (Okeson, 2015). Discrepancies in occlusion are caused by unfavorable condylar position and lead to temporomandibular joint dysfunction (TMD) (Crawford, 1999).

Orthodontic protocol requires that dental arches relation adapt to the TMJ position and not the other way around (Aubrey, 1978). Orthodontic treatment should aim at functional occlusion where CR and CO coincide (Hidaka et al., 2002).

A range of indexes created by the American Board of Orthodontics (ABO) in the 1990s such as grading system which allow to determine and quantify teeth inclination, tipping, rotation and occlusal contacts (https://www.americanboardortho.com).

Condylar axis can be evaluated using Mandibular Position indicator (MPI) (Ponces et al., 2014).

Thus, a comprehensive diagnosis and treatment can prevent the development of pathological processes from the TMJ and teeth in children in the future (Dergin and Aktop, 2014).

The aim of our study was to apply an anthropometric system of quantitative estimation 'The ABO Model Grading System' and MPI as an additional diagnostic method in children undergoing orthodontic treatment using braces.

2. Materials and methods

2.1. Ethical approval

Registration number and name of trial registry: The Local Ethics Committee of FSAEI of HE I.M. Sechenov First Moscow State Medical University of the Ministry of Health of the Russian Federation (Sechenov University). Protocol № 02-12. The study procedure was according to the World Medical Association Declaration of Helsinki.

2.2. Study design

At the department of Pediatric Dentistry and Orthodontics, First Medical Sechenov University 32 patients aged 14 to 18. They were diagnosed with crowding of the maxilla and mandible than included into treatment groups. The sample comprised 32 individuals, divided equally into two groups of 16 people each – 8 females and 8 males. This was a parallel group, randomized controlled trial with a 1:1 allocation ratio. No statistical differences were noted between genders.

All individuals and their parents signed an informed consent.

Following criteria were used: patient age – 14–18 y.o., no previous orthodontic treatment, Angle class I, crowding in both jaws was no more than 4 mm (3.3 ± 0.7 mm. the upper jaw, 2.94 ± 0.8 mm. the lower jaw).

No significant statistical changes between two groups were indicated. All patients underwent orthodontic treatment using braces to active self-ligation straight-wire technic.

Patients who were treated using the conventional protocol of orthodontic treatment were assigned to group 1.

Group 2 consisted of patients who underwent repeated re-fixation of braces using indirect bonding method at the beginning of the final stage (precise alignment), after anthropometrical measurements were performed using The ABO Model Grading System quantification method.

Patients in both groups at the beginning and at the end of orthodontic treatment were assessed for condyle deviation in a position of CO and CR using MPI.

2.3. Anthropometric study of jaws diagnostic models

Group 2 patients underwent orthodontic treatment using the anthropometric system of quantitative estimation (The ABO Model Grading System) (Fig. 1 A, B, C, D, E, F, G, H, I, J, K, L) (https://www.americanboardortho.com). Obtained result allowed to assess teeth deviations in millimetres.

2.4. Functional analysis of occlusion

At the beginning of orthodontic treatment and at the end in the both groups we analyzed dentition in CO and CR.

MPI (SAM Prazisionstechnik GmbH, Muenchen, Germany) was used to analyze the mandibular condyle shift (Mack, 1980).

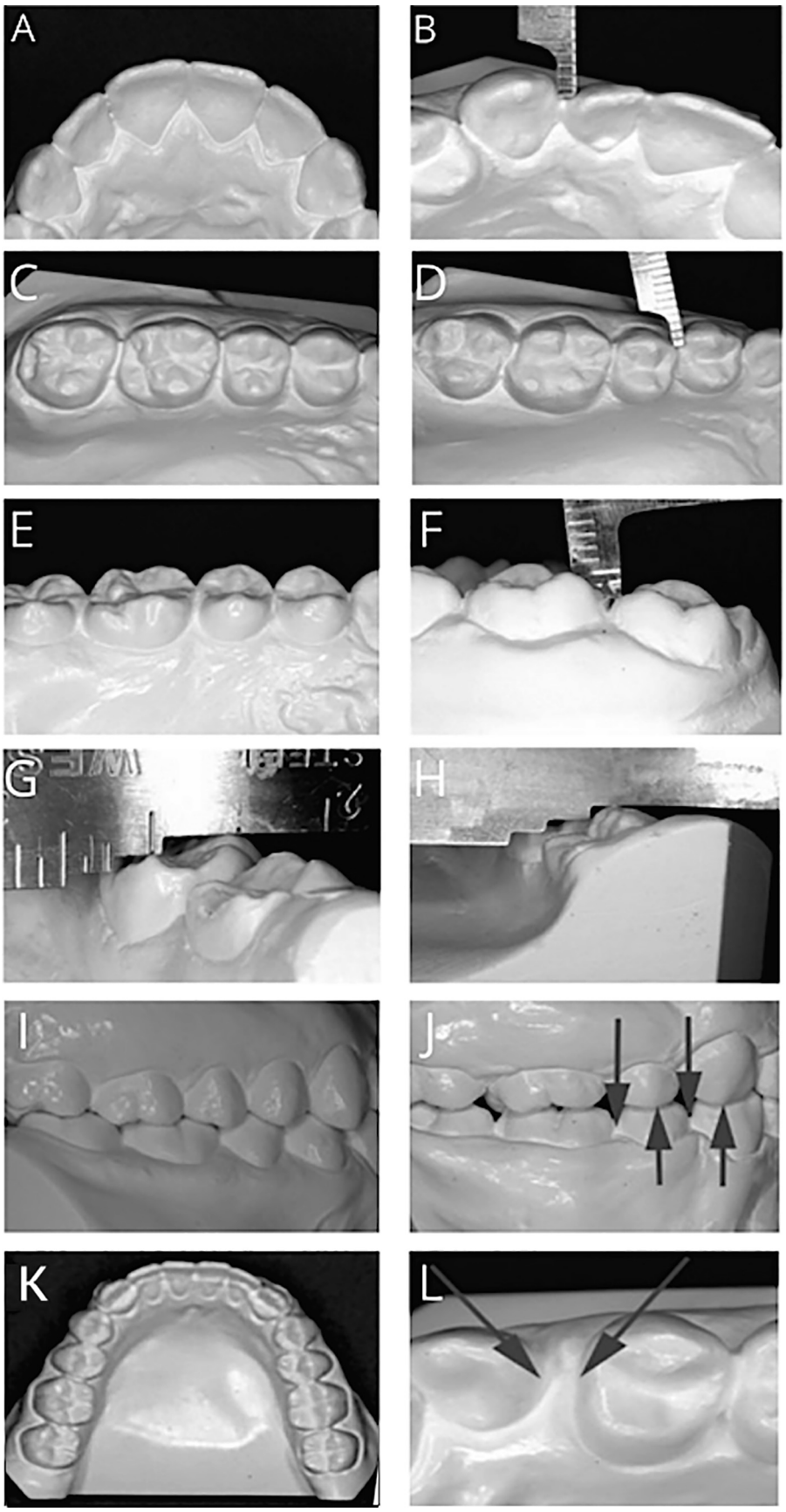

Fig. 1 The ABO Model Grading System: A- Crown alignment of the front teeth in the vestibulo-oral direction. B- Deviation. C- Crown alignment of the posterior teeth in the vestibulo-oral direction. D- Deviation. E- Alignment of the marginal ridges of the posterior teeth in the vertical direction. F- Deviation. G- Correct buccal-lingual inclination of the posterior teeth on the upper jaws. H- Deviation. I- Correct occlusal contacts in the lateral regions. J- Deviation. K- Correct approximal contacts. L- Deviation.

MPI device registers changes in lower jaw position in anteroposterior (ΔX), superoinferior (ΔZ), mediolateral (ΔY) planes graphically and allows to assess changes in millimeters. Device is a modified upper part of the SAM articulator, but instead of the articular fossae it has two sliding cubes with labels which bring it into contact with the articulation balls of the lower part of the articulator.

3. Results

3.1. Anthropometric measurements results of diagnostic casts

In group 2, patient's casts were analysed using ABO criteria at the beginning and the end of the final stage of orthodontic treatment.

At the end of the final stage following exponent criteria was determined: crown position changes of the posterior teeth in the vestibulo-oral direction (rotation) (93.75%); ratio infringement of the marginal crests of the posterior teeth in the vertical direction (65.62%); infringement of the buccal-lingual inclination of the posterior teeth (75%); infringement of occlusal contacts in the lateral parts (84.37%).

The largest number of mistakes were made when aligning the position of the lateral group of teeth on both jaws: aligning the longitudinal fissures of the first molars in the upper jaw (93.75%), longitudinal fissures of the second molars in the upper jaw (90.62 longitudinal fissures of the first molars in the lower jaw (84.37%), longitudinal fissures of the first molars in the lower jaw (76.47%).

In group 2 ABO determined effects of treatment at the final stage. It showed statistically significant decrease in the number of discrepancies (Table 1).

3.2. Results of functional analyses of teeth occlusion

Analysis of 32 patients using MPI showed incongruity between mandibular condyle position in CO and CR. However, statistically significant differences between the two groups could not be identified (Table 2).

In group 1 patients underwent treatment following the standard scheme. MPI analysis showed that in 3 (18.75%) patients the difference between CO и CR was eliminated, in 13 (81.25%) – a mismatch in the joint heads position of the mandible in CO and CR of the jaws, which later required correction.

In group 2, patients were treated using the anthropometrical system of quantitative evaluation ABO during the adjustment phase, and then re-fixing the incorrectly arranged braces by the indirect bonding method, MPI analysis in 14 patients (87.5%) showed no discrepancy between CO and CR. In 2 patients (12.5%) the difference did not exceed 0.5 mm.

Considerable correlation was observed in group 2 between bucco-lingual inclination and MPI criteria (Table 3, Fig. 2 a, b, c).

Correlation analysis between degree of change in the posterior teeth in vestibulo-oral direction position of the crowns and changes in MPI criteria in group 2 showed moderate significant correlation (Table 3).

4. Discussion

Influence of occlusal interference on the temporomandibular joint was revealed using a quantitative ABO grading system and MPI. Usiang ABO criteria, it is possible to detect occlusal interference at early stages and prevent further pathological processes and disorders in TMJ (Park et al., 2017).

J.Pson (2015) showed that rotation of the posterior teeth results in longitudinal fissures mismatch in molars and leads to occlusal interference which causes pathological changes in the TMJ (Okeson, 2015). Condition is known as "Fulcrum effect" in which occlusal contacts of the lateral group of teeth cause changes in the condyles (Kerstein, 2015).

Elimination of occlusal interferences can be achieved by using braces (Naretto, 2014). At present, there are direct and indirect bonding techniques used in orthodontic treatment (Almosa and Zafar, 2018).

Direct bonding has a lot of disadvantages in contrast to indirect bonding, especially on posterior teeth (Nawrocka and Szymanska, 2020). For precise fixation indirect bonding method is used (Proffit et al., 2019).

Our data suggests considerable statistically significant correlation in group 2. When analysing degree of bucco-lingual inclination change in lateral teeth and changes in MPI criteria, after correction of their position, CO and CR matched. This correlation between changes degree of bucco-lingual inclination change in lateral teeth and changes in MPI criteria can be explained by obvious connection between tooth position in the dental arch and condyle position within TMJ.

Table 1 Comparison of quantitative indicators of criteria for orthodontic treatment (ABO system) in group 2 at the beginning and at the end of the final stage of treatment.

ABO criterias	The beginning of the final stage		The end of the final stage		T-Wilcoxon	p- lever
	M	s	M	s		
Crown alignment of the front teeth in the vestibulo-oral direction	2.40625	0.52341	0.1875	0.359398	< 0.00001	0.000438
Crown alignment of the posterior teeth in the vestibulo-oral direction	3.375	0.806226	0.4375	0.512348	< 0.00001	0.000438
Alignment of the marginal ridges of the posterior teeth in the vertical direction	1.65625	0.72385	0.34375	0.507239	< 0.00001	0.000655
Correct buccal-lingual inclination of the posterior teeth	2.125	0.763763	0.03125	0.125000	< 0.00001	0.000438
Occlusal contacts in the lateral regions	2	0.774597	0.3125	0.478714	< 0.00001	0.001474
Occlusal contacts in the lateral regions	2.25	0.816497	0.03125	0.125000	< 0.00001	0.000438
Approximal contacts	1.03125	0.921389	0.000000	0.000000	< 0.00001	0.005062

Table 2 Comparison of results of functional occlusion analysis in groups 1 and 2 prior to treatment.

Indices of MPI	Group 1		Group 2		U-Mann-Whitney	p- lever
	M	s	M	s		
ΔX right	0.0875	0.535257	0.1	0.532917	123	0.867208
ΔX left	0.2625	0.566716	0.31875	0.515388	127.5	0.985179
ΔZ right	0.56875	0.130224	0.55	0.136626	118	0.723975
ΔZ left	0.56875	0.107819	0.56875	0.107819	126	0.955558
ΔY	0.0125	0.034157	0.000000	0.036515	113	0.589581

ΔX right – anteroposterior shift right; ΔX left – anteroposterior shift left; ΔZ right – superoinferior shift right; ΔZ left – superoinferior shift left; ΔY– mediolateral shift.

Table 3 MPI and ABO criteria in group 2 after treatment (r-Pearson).

	ΔX right	ΔX left	ΔZ right	ΔZ left
Correct buccal-lingual inclination of the posterior teeth	r = 0.7867	r = 0.4863	r = 0.9692	r = 0.8078
	p = 0.001	p = 0.066	p = 0.001	p = 0.001
Crown alignment of the posterior teeth in the vestibulo-oral direction	r = 0.4509	r = 0.3343	r = 0.5507	r = 0.4971
	p = 0.092	p = 0.223	p = 0.033	p = 0.059

ΔX right – anteroposterior shift right; ΔX left – anteroposterior shift left; ΔZ right – superoinferior shift right; ΔZ left – superoinferior shift left.

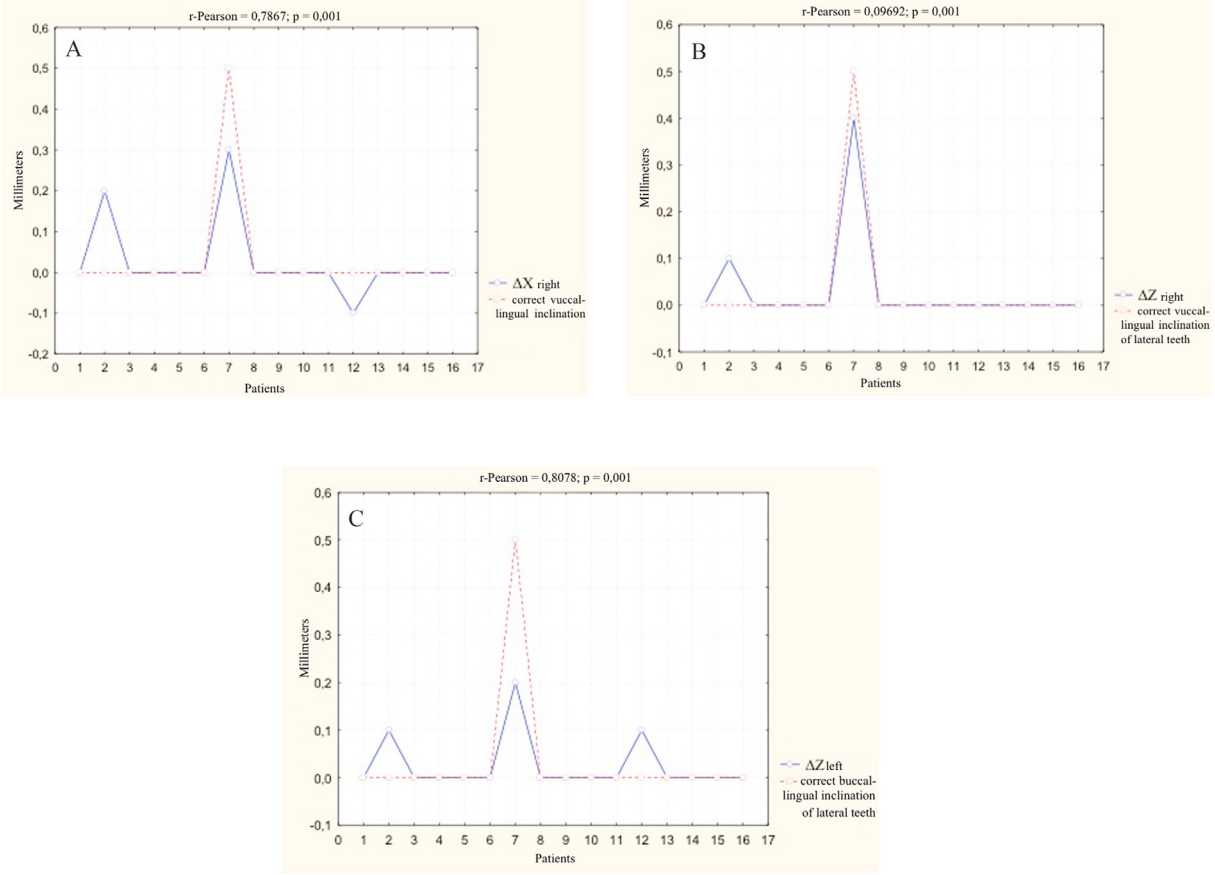

Fig. 2 Dependence of correct bucco-lingual inclination of lateral teeth from MPI criteria in group 2: A- Δ X right. B- Δ Z right. C- Δ Z left.

In group 2, anthropometrical system of quantitative evaluation ABO during the adjustment phase was used, incorrectly placed braces were re-fixed using indirect bonding method, MPI analysis in 14 patients (87.5%) showed no discrepancy between CO and CR. In 2 patients (12.5%) difference did not exceed 0.5 mm, which considered the norm. This is the worldwide concept known as «Long centric» or "Freedom in Centric" is an occlusal concept, in which a flat region is built between the retruded position and the maximum intercuspation, without a change in the vertical dimension. This flat region, having a length of 0.5–1 mm, gives the mandible freedom to close in Centric or slightly anterior to it without any interference. This is an important aspect of treatment. Dr. Rinchuse (2012) once said that occlusal interferences can cause tooth mobility, TMJ disorders, deviation or deflection on mandibular closure and movement (Rinchuse and Kandasamy, 2012).

Studies by Andrews (1989) published in his fundamental work "Straight wire. The Concept and Appliance" show that an important task is to obtain a stable result of orthodontic treatment, minimizing the possibility of relapse (Andrews, 1989). The key to obtaining a stable result is relaxed muscles of the maxillofacial region and a stable position of the condyles of the temporomandibular joint, correct statistical and dynamic occlusion, the health of periodontal structures (Grosfeld and Czarnecka, 1977, Isberg and Isacsson, 1986).

All things considered, the treatment of patients with a crowded position of the front teeth, using at the final stage of the anthropometric system of quantitative assessment of ABO with subsequent re-fixation of incorrectly placed braces by indirect bonding, effectively improves the MPI, which determines the unity of articular condyles position of the mandible in the CO and in the CR, which allows to get a stable result of orthodontic treatment.

5. Conclusion

The treatment of patients with crowding, using at the final stage an anthropometric ABO quantification system, followed by re-fixing of incorrectly placed braces using indirect bonding, helps to identify and eliminate occlusal interference.

The use of the lower jaw position indicator MPI, as a method of fast diagnostics, allows the practitioner to determine the unity of central occlusion and the central ratio, which, in turn, make it possible to obtain a stable result of orthodontic treatment, minimizing the possibility of relapse and the development of pathological processes on the part of the dentition.

Author contributions

Dudnik Olesya Viktorovna- conceived the idea, collected the data, analysed the data.

Mamedov Adil Askerovich - led the writhing.

Dybov Andrew Mikhailovich- conceived the idea

Kharke Viktoriya Valentinovna-analysed the data.

Timoshenko Tatiana Valerievna -analysed the data.

Skakodub Alla Anatolyevna - analysed the data.

Maclennan Anastasya Benediktovna -analysed the data.

Bille Diana Sergeevna- collected the data.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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