ОРТОДОНТІЯ

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MODIFIED METHOD OF DENTAL CROWDING TREATMENT DURING MIXED DENTITION

Introduction. *Modern orthodontic literature database indicates a consistently high frequency of malocclusions and dentognathic deformities that appear in children and adolescents. A huge increase in their prevalence is observed in children during the mixed dentition stage, which reaches 80%. It is also scientifically proven that with age no self-regulation of dental crowding is observed and in 80-90% of all cases it's likely to be observed during the permanent dentition period. Determination of facial skeleton growth pattern is of significant practical importance, as it allows to make the most optimal choice for treatment start, to choose correct treatment method, to predict treatment's duration and consequences. Dental crowding is one of the most common issues of orthodontics nowadays. According to worldwide literature it's prevalence reaches 77% and present at all occlusion periods, which is a significant sign of malocclusion's severity. Literature describes many methods of dental crowding treatment during mixed dentition period, which is caused by both maxillary and mandibular constriction. The most modern one is usage of Rapid Maxillary Expansion protocol (RME) with Marco-Rosa appliance. While the advantages of this aplliance are well known and scientifically proven, this appliance doesn't allow to directly expand maxillary frontal area and to create enough amount of space for anterior dental crowding regulation. That's why a new appliance for dental crowding treatment during mixed dentition was suggested by us. It's not only transversally expanding constricted maxilla but also equally expands maxillary frontal area (patent of Ukraine № 149170, 21.10.2021).* **Purpose of the study**. *Development of rational treatment protocol of patients with dental crowding during mixed dentition period according to facial skeleton growth patterns and also to make comparative analysis of treatment efficiency by using traditional and suggested protocol.* **Research methods.** *Patients in mixed dentition period with dental crowding (n=164) were examined over a period of last three years at the base of NMU O.O. Bogomolets Dental Center, Kyiv. A total of 328 CBCT sections of facial skeleton (medium FOV) before and after treatment were submitted to the general analysis.* **Scientific novelty.** *At the present stage, of interest is the effect of the newest concept of dental crowding treatment during mixed dentition according to facial skeleton growth's pattern.* **Conclusions.** *Results indicated an improvement in treatment efficiency of this pathology and significant treatment time shortening. The results obtained after 16 months in patients with a horizontal growth pattern indicate that treatment efficiency value of clinical group (CG) II patients was 58.1±1.3%; after 17 months in patients with vertical and neutral growth patterns, treatment efficiency value of CG III was 66.7±1.6%, CG I – was 52.3±0.9%. The algorithm proposed by us allows to shorten treatment duration by 3-4 months.*

Key words: *malocclusion, mixed dentition, growth pattern, facial skeleton, palatal expansion technique.*

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МОДИФІКОВАНИЙ МЕТОД ЛІКУВАННЯ СКУПЧЕНОСТІ ЗУБІВ У ЗМІННОМУ ПРИКУСІ

Мета дослідження. *Розробка раціонального протоколу лікування пацієнтів зі скупченістю зубів у змінному періоді відповідно до типів росту лицевого скелета, а також проведення порівняльного аналізу ефективності лікування за традиційним та запропонованим протоколами.* **Методи дослідження**. *Пацієнти зі скупченістю зубів у змінному прикусі (n=164) були обстежені протягом останніх трьох років на базі стоматологічного медичного центру НМУ імені О.О. Богомольця, Київ. Загалом було проаналізовано 328 КЛКТ зрізів лицевого скелета (середнє поле зору) до та після лікування.* **Наукова новизна.** *На сучасному етапі інтерес представляє ефективність нового підходу до ортодонтичного лікування скупченості зубів в змінному прикусі в залежності від наявного типу росту лицевого черепа.* **Висновки.** *Результати, отримані через 16 місяців у пацієнтів з горизонтальним типом росту, свідчать про те, що значення* *ефективності лікування пацієнтів II клінічної групи становило 58,1±1,3%; через 17 місяців у пацієнтів з вертикальним і нейтральним характером росту значення ефективності лікування клінічної групи III становило 66,7±1,6%, клінічної групи I – 52,3±0,9%. Результати свідчать про підвищення ефективності лікування даної патології та значне скорочення термінів лікування. Запропонований нами алгоритм дозволяє скоротити тривалість лікування на 3-4 місяці.*

Ключові слова: *патологія прикусу, змінний період прикусу, тип росту, лицевий череп, техніка піднебінного розширення.*

Introduction. Modern orthodontic literature database indicates a consistently high frequency of malocclusions and dentognathic deformities that appear in children and adolescents. A huge increase in their prevalence is observed in children during the mixed dentition stage, which reaches 80%. (1, c. 7, 2 c. 48-50, 3, c. 8). Moreover, the most common are class I malocclusions, which according to various authors range from 50.6% to 84.4% (7, c. 216). It is also scientifically proven that with age no self-regulation of dental crowding is observed and in 80-90% of all cases it's likely to be observed during the permanent dentition period (5, c. 435, 6, c. 756). Determination of facial skeleton growth pattern is of significant practical importance, as it allows to make the most optimal choice for treatment start, to choose correct treatment method, to predict treatment's duration and consequences(4. c. 19). Dental crowding is one of the most common issues of orthodontics nowadays. According to worldwide literature it's prevalence reaches 77% (8, c. 118) and present at all occlusion periods, which is a significant sign of malocclusion's severity. Literature describes many methods of dental crowding treatment during mixed dentition period, which is caused by both maxillary and mandibular constriction. The most modern one is usage of Rapid Maxillary Expansion protocol (RME) with Marco-Rosa appliance (9, c. 33, 10, c. 5). While the advantages of this aplliance are well known and scientifically proven, this appliance doesn't allow to directly expand maxillary frontal area and to create enough amount of space for anterior dental crowding regulation. That's why a new appliance for dental crowding treatment during mixed dentition was suggested by us. It's not only transversally expanding constricted maxilla but also equally expands maxillary frontal area (patent of Ukraine № 149170, 21.10.2021). The aim of research was to develop rational treatment protocol of patients with dental crowding during mixed dentition period according to facial skeleton growth patterns and also to make comparative analysis of treatment efficiency based on cone-beamed computed tomography (CBCT) data by using traditional and suggested treatment protocol.

Materials and methods. For three years (2020-2022), we examined and treated patients with dental crowding at the Dental Medical Center of the Bogomolets National Medical University named. The research was carried out in compliance with the main provisions of the "Rules of Ethical Principles of Scientific Medical Research with Human Participation" approved by the Helsinki Declaration (1964-2013), ICH GCP (1996), EU Directive No. 609 (from November 24, 1986), orders of the Ministry of Health of Ukraine No. 690 dated September 23, 2009, No. 944 dated December 14, 2009, No. 616 dated August 3, 2012. All participants were informed about the purpose and methods of the study and signed an informed consent to participate in it, and all measures were taken to ensure patient anonymity. The criteria for randomization of patients were next: mixed dentition period (7-11 years), the presence of dental crowding in maxillary and/or mandibular frontal area, erupted first permanent molars, the absence of general somatic diseases. Research included 164 people, 64 (39.1%) patients were male, and 100 (60.9%) patients were female. The distribution of examined patients according to the facial skeleton growth pattern is shown in Table 1. According to the algorithm developed by us, all patients who entered the examination groups were subjected to diagnostics before and after treatment. A total of 328 CBCT slices of the facial skull (medium FOV) of the patients at the beginning and after the treatment were analyzed. On CBCT slices we evaluated changes in width of both maxilla and mandible at basal arches

Table 1

Distribution of patients according to facial skeleton growth pattern and gender

Growth pattern	Group of control, n= 20		Clinical group I, n=44		Clinical group II, n=48		Clinical group III, n=52	
	male	female	male	female	male	female	male	female
horizontal	2	3	-	-	18	30	-	-
neutral	4	5	12	32	-	-	-	-
vertical	3	3	-	-	-	-	21	31

(in the projection of the first permanent molars between the most convex points of the cortical plate, departing from the enamel-cement junction by 8 mm in the direction of the apex of the root) and alveolar arches (in the projection of the first permanent molars between the most convex points of the alveolar process, receding from the enamel-cement junction by 3 mm in the direction of the apex of the root) levels before and after treatment, and changes of dental crowding severity were also evaluated according to the Little's Irregularity Index values.

The generally accepted algorithm for dental crowding treatment is applying RME protocol has 2 phases, consisting fixation of Marco-Rosa appliance (**figure 1**) on maxilla and the activation of a 10 mm screw, once every 2 days at 90°, the active phase of screw activation is 64 days (2 months), after the end of the active phase this appliance remains in the oral cavity for 6 months as a retention. After the RME protocol, if necessary, a myofunctional trainer is additionally prescribed for 12 months with a wearing regime of 12 hours per day.

All patients had clinically significant dental crowding and were distributed into the clinical groups according to their facial skeleton growth patterns.

1. First clinical group – 44 patients (30,5%).
2. Second clinical group – 48 patients (33,3%).
3. Third clinical group – 52 patients (36,2%).

The first clinical group consisted of patients with a neutral type of growth of the bones of the facial skull, the second clinical group included patients with a vertical type of growth of the bones of the facial skull, and the third clinical group included patients with a horizontal type of growth of the bones of the facial skull.

The patients of each clinical group were treated according to our proposed algorithms and standarded: the first phase of orthodontic treatment consisted of suggested appliance fixation on maxillary dental arch with existing beams adjacent to the lateral group of teeth and protracting arches in the frontal area (**figure 2**), together with a fixation of Williams fixed mandibular expander (**figure 3**); the second phase consisted in prescription of myofunctional appliance depending on the presented malocclusion. Main differences in treatment protocols are represented in Table 2.

In the 1st clinical group, 30 people were treated according to the algorithm proposed by us (**table 2**): the appliance's screw proposed by us (figure 1) is activated once a day, the active phase is 32 days (1 month), fixed mandibular expander by Williams is installed 2 weeks after the start of treatment and is

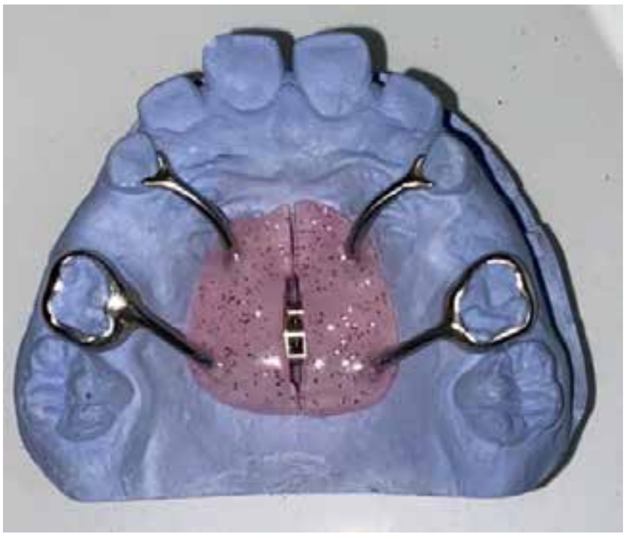

Fig. 1. Marco-Rossa appliance

Fig. 2. Proposed by us appliance

Fig. 3. Williams fixed mandibular expander

Table 2

Comparison of treatment protocols

Steps	Standarded protocol	Modified protocol
1.Manufacture and fixation of fixed orthodontic appliance for the maxillary expansion by using RME protocol.	Marco-Rosa appliance	Appliance for dental crowding treatment in mixed dentition (Patent of Ukraine № 149170, 2021p.)
2.Scheme of screw activation and general treatment duration with an appliance.	Activation: once per 2 days Treatment duration: 8 months	Activation: once per day Treatment duration: 7 months
4. Manufacture and fixation of fixed orthodontic appliance for the mandibular arch expansion.	Fixed mandibular expander by Williams	Fixed mandibular expander by Williams
5. Scheme of screw activation and general treatment duration with an appliance.	Activation: once per 4 days Treatment duration: 6.5 months	Activation: once per 3 days Treatment duration: 6.5 months
6. Simultaneous removal of both fixed appliances. Prescription of myofunctional appliance according to malocclusion.	+	+
7. Prescription of myofunctional appliance scheme of use according to presented facial skeleton growth patterns in different clinical groups.	–	+
8. Scheme of myofunctional appliance usage	12 hours/day during a year	CG1: 16 hours per day/ 10 months CG2: 18 hours per day/ 9 months CG3: 19 hours per day/ 10 months
9. General treatment time	20 months	CG1: 16 months CG2: 16 months CG3: 17 months

activated once per 3 days, active phase – 1.5 months. Both devices remain in the oral cavity for a retention period of 6 months. After immediate removal of the devices, a myofunctional trainer is prescribed for 10 months: the mode of use is 16 hours a day, every day and total duration of treatment was 17 months; 14 people were treated according to the standard algorithm **(table 2)**: the screw of Marco-Rosa appliance is activated once per 2 days, the duration of the active phase of treatment is 64 days (2 months), the retention period is 6 months. After 3 weeks from the start of treatment, an installation of fixed mandibular expander by Williams with an activation scheme once per 4 days, the duration of the active phase of treatment is 1.5 months, and the retention period is 5 months. After immediate removal of the devices, a myofunctional trainer is prescribed for 12 months. Mode of use: 12 hours a day. Total duration of treatment was 20 months. Clinical results are represented on **figure 4.**

In the II clinical group, 36 people were treated according to the algorithm proposed by us: the appliance's screw proposed by us is activated once a day, the active phase is 32 days (1 month), fixed mandibular expander by Williams is installed 2 weeks after the start of treatment and is activated once per 3 days, active phase – 1.5 months. Both devices remain in the oral cavity for a retention period of 6 months. After immediate removal of the devices, a myofunctional trainer is prescribed for 9 months: the mode of use is 18 hours per day, every day. Total duration of treatment was 16 months; 12 people were treated according to the standard algorithm: the screw of Marco-Rosa appliance is activated once per 2 days, the

Fig. 4. Proposed protocol in CG1 (left- before; right – after treatment)

duration of the active phase of treatment is 64 days (2 months), the retention period is 6 months.

After 3 weeks from the start of treatment, an installation of fixed mandibular expander by Williams with an activation scheme once per 4 days, the duration of the active phase of treatment is 1.5 months, and the retention period is 5 months. After immediate removal of the devices, a myofunctional trainer is prescribed for 12 months. Mode of use: 12 hours per day. Total duration of treatment was 20 months. Clinical results are represented on **figure 5**.

In the III clinical group, 30 people were treated according to the algorithm proposed by us: the appliance's screw proposed by us is activated once a day, the active phase is 32 days (1 month), fixed mandibular expander by Williams is installed 2 weeks after the start of treatment and is activated once per 3 days, active phase – 1.5 months. Both devices remain in the oral cavity for a retention period of 6 months. After immediate removal of the devices, a myofunctional trainer is prescribed for10 months: the mode of use is 19 hours per day, every day. The effectiveness of the treatment was 66.7±1.6%, the total duration of treatment was 17 months; 16 people were treated according to the standard algorithm: the screw of Marco-Rosa appliance is activated once per 2 days, the duration of the active phase of treatment is 64 days (2 months), the retention period is 6 months. After 3 weeks from the start of treatment, an installation of fixed mandibular expander by Williams with an activation scheme once per 4 days, the duration of the active phase of treatment is 1.5 months, and the retention period is 5 months. After immediate removal of the devices, a myofunctional trainer is prescribed for 12 months. Mode of use: 12 hours a day. Total duration of treatment was 20 months. Clinical results on diagnostic models are represented on **figure 6.**

The control group consisted of 127 people. Those patients were treated according to standarded treatment protocol (**table 2**) which also was used in minority of clinical group subjects. Clinical results on diagnostic models are represented on **figure 7.**

The data we received were analyzed, interpreted and statistically processed. Statistical processing of these data included a number of parametric and non-parametric criteria of statistical methods. The analysis was performed using statistical packages MedStat and EZR v. 1.35 (Saitama Medical Center, Jichi Medical University, Saitama, Japan 2017). Statistical analysis of materials, summarization of results, and generalization of conclusions were per-

Fig. 5. Proposed protocol in CG2 (upper – before; lower – after treatment)

Fig. 6. Proposed protocol in CG3 (left – before; right – after treatment)

formed using the method of variational statistics, taking into account average values (mode, median, arithmetic mean) and average error (M) with evaluation of reliable values according to the Wilcoxon t-test. A value of $p<0.05$ was taken as the minimum probability threshold.

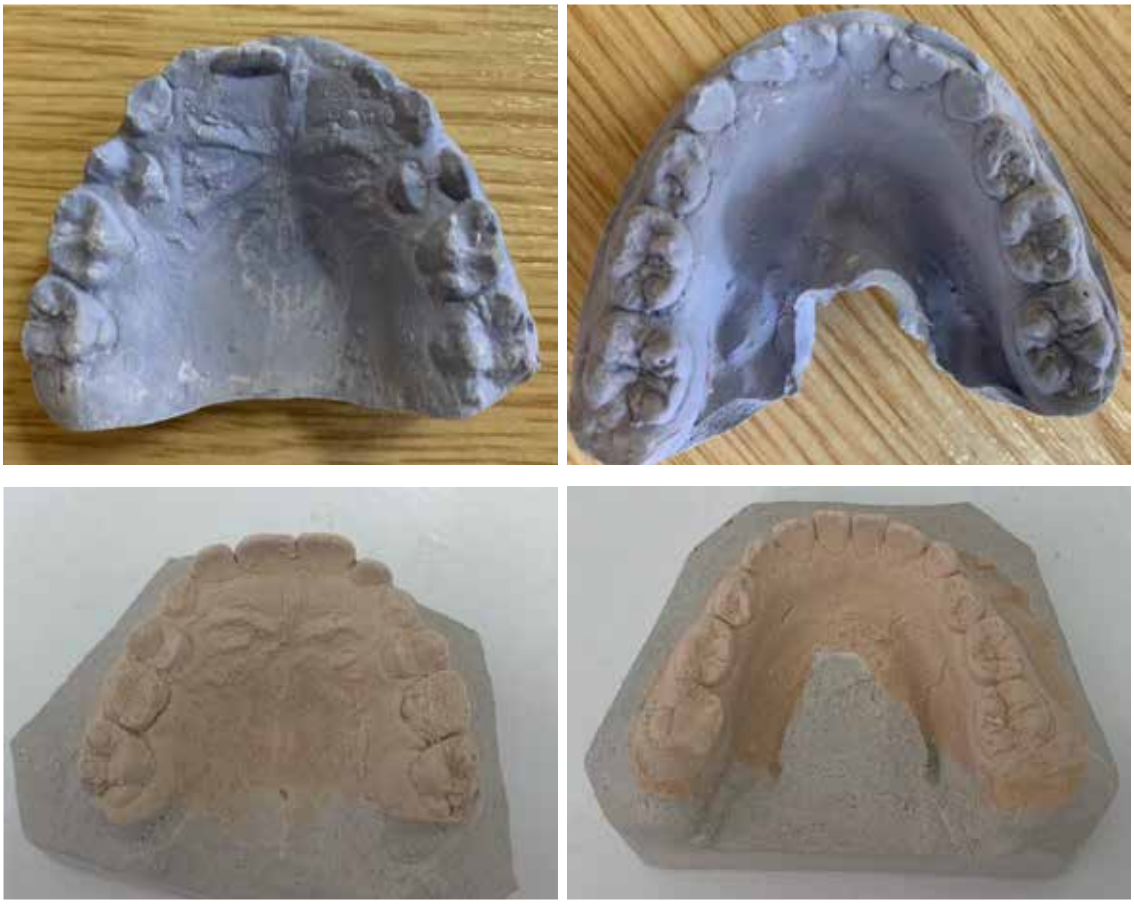

Fig. 7. Standarded protocol in control group (upper – before; lower – after treatment)

To compare obtained values of basal arch width and alveolar arch width of both jaws and Little's Irregularity Index on maxilla and mandible before and after treatment, appropriate comparison criteria for related samples were used. Kruskel–Wallis test was used for quantitative indicators. During the statistical analysis, criteria with a two-sided critical area were used, with the critical level of significance being p=0.05.

Results. According to research results (**table 3**), it was established that when using the proposed protocol in CG 1, the skeletal effect of the maxillary expansion (BAMxW) is 4.8±1.1 mm, the alveolar effect of the expansion of maxilla (AAMxW) is 4.9±0.8 mm., expansion of mandible at the basal level (BAMdW) was 3.0±0.7 mm, while at the alveolar level (AAMdW) 5.9 ± 1.2 mm was reached; at the same time, we managed to reduce the Little's Irregularity Index value of upper teeth (LIIMx) by 12.2 ± 1.5 mm, the Little's Irregularity Index value of lower teeth(LIIMd) by 9.3 ± 0.8 mm, i.e., we were able to transfer the severity of crowding from severe to mild on both maxilla and mandible. The effectiveness of the treatment was 52.3±0.9% (p=0,005).

When using the proposed protocol in CG 2, the skeletal effect of the maxillary expansion (BAMxW) is 4,8±0,6 mm, the alveolar effect of the expansion of maxilla (AAMxW) – 4,2±0,6 mm., expansion of mandible at the basal level (BAMdW) was 3,2 ±0,4 mm, while at the alveolar level (AAMdW) – 4,1 ± 0,7 mm; at the same time, we managed to reduce the Little's Irregularity Index value of upper teeth (LIIMx) by 13,1 ± 1,2 mm, the Little's Irregularity Index value of lower teeth(LIIMd) by 6,9±1,4 mm, i.e., we were able to transfer the severity of crowding from severe to mild on both maxilla and mandible. The effectiveness of the treatment was 58,1±1,7% (p=0,005).

When using the proposed protocol in CG 3, the skeletal effect of the maxillary expansion (BAMxW) is 6,3±0,7 mm, the alveolar effect of the expansion of maxilla (AAMxW) – 5,2±0,9 mm., expansion of mandible at the basal level (BAMdW) was 3,6±0,8 mm, while at the alveolar level (AAMdW) – 4,7±1,1 mm; at the same time, we managed to reduce the Little's Irregularity Index value of upper teeth (LIIMx) by 11,9 ± 1,7 mm, the Little's Irregularity Index value of lower teeth(LIIMd) by 6,9±1,4 mm, i.e., we were able to transfer the severity of maxillary crowding from severe to moderate, from severe to mild on mandible. The effectiveness of the treatment was 66,7±1,6% (p=0,005).

Table 3

CBCT data values in clinical groups by suggested protocol

CBCT data	CG I			
	Before treatment	After treatment	Treatment efficiency	p-value
BAMxW	58,7 ±1,6 mm	62,1 ± 0,9 mm	52,3±0,9%	p<0,05
AAMxW	56,2 ± 2,3 mm	60,9 ± 1,3 mm		p<0,05
BAMdW	56,8 ± 1,2 mm	58,7 ± 0,6 mm		p<0,05
AAMdW	55,5 ± 2,1 mm	59,6 ± 1,4 mm		p<0,05
LIIMx	18,1±3,5 mm	6,4 ± 1,5 mm		p<0,05
LIIMd	13,9± 2,4 mm	4,6±3,2 mm		p<0,05
CBCT data	CGII			
	Before treatment	After treatment	Treatment efficiency	p-value
BAMxW	58,9 ±1,8 mm	63,2 ± 1,7 mm	58,1±1,7%	p<0,05
AAMxW	56,5 ± 2,1 mm	61,4 ± 1,3 mm		p<0,05
BAMdW	57,1 ± 1,4 mm	59,4 ± 0,9 mm		p<0,05
AAMdW	55,9 ± 2,6 mm	60,8 ± 2,4 mm		p<0,05
LIIMx	17,8±2,9 mm	4,7 ± 1,8 mm		p<0,05
LIIMd	11,7± 2,5 mm	4,8±1,1 mm		p<0,05
CBCT data	CGIII			
	Before treatment	After treatment	Treatment efficiency	p-value
BAMxW	55,6 ±1,3 mm	62,7 ± 1,5 mm	66,7±1,6%	p<0,05
AAMxW	53,2 ± 2,5 mm	58,9 ± 2,3 mm		p<0,05
BAMdW	54,8 ± 1,5 mm	58,7 ± 0,6 mm		p<0,05
AAMdW	55,2 ± 2,1 mm	57,5 ± 2,9 mm		p<0,05
LIIMx	18,1±3,5 mm	6,4 ± 1,5 mm		p<0,05
LIIMd	13,9± 2,4 mm	2,9±0,5 mm		p<0,05

Evaluating the results of treatment using a standard protocol, we found that in patients with neutral growth the skeletal effect of maxillary expansion was 2,7±0,6 mm, alveolar effect of expansion was 2,4±0,8 mm., the skeletal effect of mandibular expansion was 1,8±0,5 mm, while at the alveolar level mandibular expansion was 3,9 ± 0,8 mm; at the same time, we managed to reduce the Little's Irregularity Index value of upper teeth by 5,8 ± 1,5 mm, at the same time, we managed to reduce the Little's Irregularity Index value of lower teeth by 4,3±0,5 mm,, i.e., we were able to transfer the severity degree of crowding only from severe to moderate on both maxilla and mandible. The effectiveness of the treatment was 25,6±1,7% (p=0,005).

Patients with horizontal growth had lesser skeletal effect of maxillary expansion –2,5±0,8 mm, alveolar effect of expansion was 3,6±1,3 mm., the skeletal effect of mandibular expansion was 2,1±0,5 mm, while at the alveolar level mandibular expansion was 2,8 ± 0,7 mm; at the same time, we managed to reduce the Little's Irregularity Index value of upper teeth by 6,2 ± 1,4 mm, we managed to reduce the Little's Irregularity Index value of lower teeth by 5,1±0,7 mm, were able to transfer the severity degree of crowding from severe to moderate on both maxilla and mandible. The effectiveness of the treatment was 22,3±2,1% (p=0,005).

Patients with vertical growth had better skeletal effect of maxillary expansion –3,4±0,9 mm, alveolar effect of expansion was 2,9±0,5 mm., the skeletal effect of mandibular expansion was 3,3±0,4 mm, at the alveolar level mandibular expansion was 3,8 ± 1,3 mm; at the same time, we managed to reduce the Little's Irregularity Index value of upper teeth by 4,2 ± 1,3 mm, at the same time, we managed to reduce the Little's Irregularity Index value of lower teeth by 3,4±0,3 mm, were able to transfer the severity degree of crowding from severe to moderate on both maxilla and mandible. The effectiveness of the treatment was 29,5±2,4% (p=0,005).

Discussion. Comparing the obtained results of the effectiveness of the treatment with the results of the effectiveness of the treatment of tooth crowding in variable bite according to traditional methods (Alsawaf, Almaasarani & Hajeer, 2022; Caroccia, Moscagiuri & Falconio, 2020) a significant difference in quantitative data was observed. Thus, the effectiveness of treatment of patients of CG III reached 66.7±1.6% (for the results obtained from patients who were treated according to the traditional algorithm, this indicator was 29.5±2.4%); CG II – up to 58.1±1.3% (for the results obtained in patients who were treated according to the traditional algorithm, this indicator was 22.3±2.1%); CG I – 52.3±0.9% (for the results obtained in patients who were treated according to the traditional algorithm, this indicator was 25.6±1.7%).

Conclusions. The results of our conducted statistical analysis of the proposed protocol application efficiency of dental crowding treatment allowed to improve treatment quality of this pathology in children. The results obtained after 16 months in patients with a horizontal type of growth indicate that the effectiveness of the treatment of CG II patients reached 58.1±1.3% (p=0,005); after 17 months, in patients with a vertical and neutral type of growth, the effectiveness of the treatment of CG III reached 66.7±1.6% (p=0,005), CG I – up to 52.3±0.9% (p=0,005). Our proposed algorithm is more effective in patients with a neutral type of growth by 26.9 ± 1.2% (p=0,005), in patients with a vertical type of growth by 37.3 ± 0.7% (p=0,005). and allows to shorten their total treatment period by 3 months; more effective in patients with a horizontal type of growth by 35.8 ± 0.9% (p=0,005). and allows to shorten their total treatment period by 4 months.

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