



Treating Gnathic form of Mesial Occlusion in Early Adolescence Patients: A Clinical Trial

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Abstract

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AIM: The aim of the study was to evaluate the early and late results of the non-surgical orthopedic treatment efficiency in 12–14 years old children with the gnathic forms of mesial occlusion by the dentoalveolar compensation utilizing a permanent device with a palatal expanding screw.

METHODS: The study enrolled 26 patients aged 12–14 years who underwent orthopedic treatment by the dentoalveolar compensation using a permanent device with a palatal expanding screw. Late treatment results aged 4–6 years were analyzed for 21 patients by cephalometric indices, five patients were excluded from the study due to change of residence. The comparison group included 20 patients of the same age and diagnosis who received orthopedic treatment with a face mask.

RESULTS: The method of treatment utilizing a permanent apparatus with a palatal expanding screw showed better results than the facemask therapy. More pronounced changes of the general growth vector of the facial skeleton toward the maxilla normalization were noted. The anteroposterior relations between the jaw bases were normalized, the normal position of the upper and lower incisors was achieved, a stable interincisal angle was formed, and the aesthetics of the facial profile significantly improved.

CONCLUSIONS: Using a fixed apparatus with a palatal expanding screw has significantly improved patients' morphological, physiological, and esthetic performance. The evaluation of late results (from 4 to 6 years) showed normal development of the dentistry system in 90.5% of cases that allowed avoiding surgical intervention in these patients after the end of skeletal growth.

Introduction

One of the most challenging problems in modern orthodontic practice is treating patients with a gnathic (skeletal) mesial occlusion. The number of patients with this pathology and the number of severe gnathic forms have been steadily increasing recently [1], [2]. The reason for this is untimely diagnostics and insufficiently developed system of assisting patients with mesial occlusion, and, consequently, the progression of the pathology with age [3], [4], [5]. According to Angle's morphological classification of dental anomalies, mesial occlusion is classified as Class III anomalies that account for around 13% of all dentistry anomalies [3], [4], [6].

The given pathology is formed at the maldevelopment of jawbones (gnathic forms) or dental and alveolar arches [7], [8]. Gnathic forms of mesial occlusion are usually formed under the influence of endogenous factors such as heredity and endocrine disorders. The share of hereditary anomalies at that amounts to up to 25% [9].

Anomalies in the jaw sizes (macro- and micrognathia) and their position in the skull (pro- and

retrognathia) are associated with the hereditary factor. The presence of only mandible macrognathia or maxilla micrognathia in patients with a gnathic mesial occlusion is found in 40–50% of cases, the combination of skeletal mandible and maxilla anomalies – in 50–60%. Endocrine disorders promote the growth of bony and cartilaginous zones of the facial skull, disturbance of the skull base and mandible, and disproportion between the jaws and gnathic forms of mesial occlusion [10].

Mesial occlusion appears from an early age and is formed until the end of growth [11]. At the age of 6–9 years, clinical manifestations of gnathic and tooth and alveolar forms of mesial occlusion are similar. Thus, in most cases, a displacement of the lower jaw forward is detected, which may cause additional growth of the lower jaw [12], [13].

The anomaly is aggravated in the mixed bite at an older age if mesial occlusion was not corrected during temporary teeth occlusion. The deviations in facial proportions become more evident and generally asymmetric [14], [15], [16], [17], leading to significant esthetic defects resulting in personal and psychological problems in children [18].

If teenage patients with gnathic mesial occlusion have not previously received appropriate

treatment, they have lower macrognathia combined with the mandible underdevelopment in most cases [19]. Development disorders in the anterior part of the skull base are observed as well [4]. If clinical manifestations of mesial occlusion at earlier stages of the dentistry system development were not treated adequately, the secondary deformations of dental rows and underdevelopment of the maxilla may then be also counted for genetically caused anomalies [20].

At present, unified approaches to the treatment tactics of adolescents with gnathic forms of mesial occlusion are not developed, and the known methods are not effective enough. Many patients are left untreated until their skeletal growth is complete, and only after reaching the age of 18, they receive appropriate orthodontic and surgical treatment [21], [22]. It should be noted that the results of surgical intervention in adolescents are poorly predictable due to the ongoing skeletal growth.

In this regard, establishing effective orthopedic treatment methods for adolescents with this anomaly is an urgent problem. The treatment process requires solving such problems as harmonization of the dental system development, reducing the need for surgery, as well as aesthetic and social rehabilitation of adolescents with this anomaly [23], [24].

Therefore, the primary purpose of this study was to evaluate the immediate and previous results of the effectiveness of non-surgical orthopedic treatment in children aged 12–14 years with gnathic forms of mesial occlusion by the method of dentoalveolar compensation using a permanent apparatus with a palatal expanding screw.

Materials and Methods

Study design

This research was a comparative clinical trial conducted from September 2014 to October 2020. The sample size was calculated using the t-test power calculation in the R statistical package (version 3.4.2), with an effect size of 0.40, a significance level of 0.05, and a study power of 0.80.

The study included 46 patients aged 12–14 years who underwent orthopedic treatment. All patients were divided into two groups:

1. The experimental group included 26 patients — orthopedic treatment was performed using the dentoalveolar compensation method with permanent apparatus with a palatal expanding screw. After 4–6 years, treatment results of 21 patients were analyzed, five patients were excluded from the study due to a change of residence
2. The comparison group included 20 patients — orthopedic treatment was performed using a face mask.

Inclusion criteria

Morphological and radiological signs for the gnathic form of mesial occlusion and the average anomaly severity were included in the study.

Exclusion criteria

Severe form of gnathic mesial occlusion, functional and organic pathology of the temporomandibular joint, and congenital anomalies of the dento-maxillofacial area (cleft upper lip and palate) were excluded from the study.

Follow-up and data collection

Appropriate treatment tactics were defined according to external examination results, orthopantomogram, cephalometric analysis with telerradiography using Dolphin imaging program (USA), biometric examination of models for jaw diagnostics, and complex quantitative estimation of mesial occlusion severity degree. Orthopedic treatment results were evaluated using lateral projection telerradiography analysis. The long-term treatment results (4–6 years) were analyzed to assess the effectiveness of the proposed dentoalveolar compensation method using a permanent device with a palatal expansion screw. The results of treating children applying upper retrosternal and micrognathia orthopedic correction with facial mask treatment were compared to substantiate the advantages of the proposed method. In cephalometric analysis, the following standard indicators were used:

1. Sella-Nasion to Subspinal Point Angle (SNA) – measures the position of the maxilla relative to the anterior cranial base
2. Sella-Nasion to Supramental Point Angle (SNB) – measures the position of the mandible relative to the anterior cranial base
3. Subspinal Point to Supramental Point Angle (ANB) – measures the anteroposterior relationship between maxilla and mandible
4. Line condylion to Subspinal Point (Co-A) – measures the maxillary length
5. Line condylion to gnathion (Co-Gn) – measures the mandibular length
6. Line Connecting Anterior Nasal Spine Point to Menton (ANS-Me) – reflects the anteroinferior height of the face
7. Overbite – extent of vertical (superior-inferior) overlap of the maxillary central incisors over the mandibular central incisors measured relative to the incisal ridges

8. Overjet – the extent of horizontal (anteroposterior) overlap of the maxillary central incisors over the mandibular central incisors
9. Axis of upper incisor to Nasal line Angle (ILS/NL) – measures the inclination of the upper incisors
10. Axis of the lower incisor to Mandibular line Angle (ILi/ML) – measures the inclination of the lower incisors
11. Axis of the upper incisor to Axis of the lower incisor Angle (ILS/ILi)
12. Angle of facial convexity (gl-sn-pg) – expresses the maxilla-mandibular anteroposterior relationship
13. Nasolabial Angle (cm-sn-pg) – indicates the position of the maxilla, dentition, thickness of the upper lip, and the inclination of the alar border of the nose
14. The “Wits” appraisal of jaw disharmony.

Orthopedic treatment with the dentoalveolar compensation method using permanent device with a palatal expanding screw

A permanent device with a palatal expanding screw was installed on the fourth and sixth teeth of the maxilla. The initial position of the screw corresponded to the anatomical distance between the side parts of the alveolar ridge of the patient's maxilla. After the device installation, the maxilla was widened, narrowed, and re-widened alternately, turning the palatal screw to the appropriate side for 10 days per stage. Expansion or contraction was performed once a day with a 0.4 mm pitch. After the second enlargement, the position of the palatal screw was fixed. Orthodontic implants were placed on both sides of the mandible between the third and fourth permanent teeth.

Afterward, intermaxillary traction (330–400 g per side) was applied on the outer side of the jawbone from the implants on the mandible to the hooks fixed on the permanent device outside in the area of the sixth teeth. Patients wore traction around the clock, except for mealtimes, 2–3 months until the back overbite was removed. Eventually, a final correction of the relationship between the tooth rows was made using permanent orthodontic appliances to achieve physiological occlusion.

Thus, in this treatment method, a permanent device with a palatal screw was used to expand the palatine suture and mobilize the maxilla by destabilizing the sutures of the maxilla affecting the formation of mesial occlusion, that is, median palatine suture, the suture between the halves of the alveolar ridges, incisal sutures, and suture between the nasal and palatal plates.

Statistical data processing

The Statistica 10 software for Windows was used for statistical data processing. A mean value, standard deviation, arithmetic mean error, and variation factor was measured for all indicators. The critical level of p significance was accepted to be 0.05.

Ethical declaration

This study was agreed to by the Standing Committee on Research Ethics before it began. The study was carried out according to the fundamental ethical principles recognized in international practice and set out in the Declaration of Helsinki. All patients' parents have signed written consent for their children to participate in the experiment. All parents were assured of anonymity and confidentiality.

Results

External examination of patients in full-face showed a decrease in the length of the upper lip, pronounced nasolabial folds, supra-mental sulcus was weakly evident or totally reduced. When assessing the patients' contour, the concave profile, retraction of the upper lip, upper lip shortening, mesial lip step, and underdevelopment of the midface were noted. When examining the oral cavity, Class III was revealed in all patients, according to Engle. In 90% of cases, the upper tooth row was narrowed.

According to the analysis of lateral cephalograms (Table 1), the SNA angle value in patients before the treatment was 76.58 ± 2.12 (reference 82 ± 2), and the marked upper retrognathia was registered. The mean value of the ANB angle value was negative and amounted to -4.41 ± 1.77 (reference 2 ± 2). The maxilla retroposition was detected in 80% of patients, the mandible anteposition – in 64% of cases, and a combination of these deviations were recorded in 32% of cases.

All patients had an apparent disproportion of cephalometric jaw sizes (13.88 ± 1.35 mm). The mean angle value of ILS\NL before the treatment was within the normal range, amounting to 116.90 ± 2.85 . However, in 27% of cases, a slight protrusion of the maxilla incisors was observed. The ILi/ML angle value was 83.57 ± 2.87 (reference 90 ± 5), that is, the retrusion of lower incisors occurred. The negative value of “Overjet” was observed in all cases and averaged -2.37 ± 1.24 mm. Hypodivergent type of facial skeleton structure was diagnosed in 86% of patients. The Angle of facial convexity (gl-sn-pg) was 107.34 ± 13.43 on average, which is considerably lower than the reference value (168 ± 5). The average value of the “Wits” number

Table 1: Cephalometric data of patients with gnathic forms of mesial occlusion before and after orthopedic treatment

Indicators	Average rate	Before treatment	Treatment results	Changes in indicators	p
SNA	82 ± 2	76.58 ± 2.12	77.42 ± 1.95	0.84 ± 0.31↑	>0.05
SNB	80 ± 2	82.12 ± 1.87	80.87 ± 2.76	1.25 ± 0.43↓	<0.05
ANB	2 ± 2	-4.41 ± 1.77	-1.34 ± 0.78	3.07 ± 0.52↓	<0.05
Overbite	1-3 mm	-2.46 ± 1.21	-0.65 ± 0.34	1.81 ± 76↓	<0.05
Overjet	1-1.5 mm	-2.37 ± 1.24	1.12 ± 0.76	3.49 ± 1.83↓	<0.05
Co-A	-	76.97 ± 2.47	79.77 ± 3.03	2.8 ± 0.19↑	
Co-Gn	-	112.872.95	115.983.12	3.11 ± 0.65↑	
ANS-Me	-	57.86 ± 3.65	61.43 ± 3.48	3.57 ± 2.26↑	
ILS/NL	115 ± 5	117.59 ± 3.15	118.03 ± 2.87	0.44 ± 0.14↑	<0.05
ILi/ML	90 ± 5	83.57 ± 2.87°	82.28 ± 2.74	1.29 ± 0.27↓	<0.05
ILS/ILi	125 ± 5	133.68 ± 3.67	132.14 ± 4.03	1.54 ± 0.46↓	<0.05
gl-sn-pg	168 ± 5	107.34 ± 13.43	168.96 ± 15.14	61.62 ± 9.21↑	<0.05
cm-sn-pg	105 ± 10	109.33 ± 6.61	110.25 ± 3.65	0.92 ± 0.12↑	<0.05
Wits	0-4 mm	7.46 ± 1.67	4.27 ± 1.65	3.19 ± 1.04↓	<0.05

SNA: Sella-Nasion to Subspinal Point Angle, SNB: Sella-Nasion to Supramental Point Angle, ANB: Subspinal Point to Supramental Point Angle, Co-A: Line condylin to Subspinal Point, Co-Gn: Line condylin to gnathion, ILS/NL: Axis of upper incisor to Nasal line Angle, ILi/ML: Axis of lower incisor to Mandibular line Angle, ILS/ILi: Axis of upper incisor to Axis of lower incisor Angle, gl-sn-pg: Angle of facial convexity, cm-sn-pg: Nasolabial Angle.

was 7.46 ± 1.67 mm, which corresponds to the average degree of the anomaly and suggests treatment with the removal of mandible teeth, in two patients the value of “Wits” number exceeded 8 mm, which indicates the need for combined orthodontic and surgical treatment.

After orthopedic treatment in the experimental group (Table 1), the SNA angle increased by 0.84 ± 0.31 , which indicates an improvement in the position of the maxilla. The decrease of the ANB angle by 3.07 ± 0.52 shows an improvement in the jaw size ratio. The sizes of the facial convexity angle and the nasolabial Angle have reached values close to normal. Change of facial profile type from concave before treatment to convex after treatment was observed, showing the jaw complex’s correct development.

An increase in the size of the upper jaw (So-A) by 2.8 ± 0.19 mm was noted. However, the growth of the mandible (Co-Gn) continued, and its size increased from 112.87 ± 2.95 mm before treatment to 115.94 ± 3.12 mm afterward. The angle value ILS/NL (118.03 ± 2.87) remained close to normal, which shows that the installed orthopedic device did not influence the position of the upper incisors but affected the maxilla. The improvement of the “Wits” number to 4.27 ± 1.65 mm was noted, that is, the degree of the anomaly severity changed from the average to the light after treatment. It allows for orthopedic treatment without teeth extraction instead of orthodontic surgery.

At estimation of late treatment results of 4–6 years, it was found that 19 (90.5%) out of 21 examined patients had physiological occlusion of dental rows and regular intercuspatation contacts. Face esthetics looked harmonious, and the satisfaction with treatment results among patients and their parents was noted. Excessive growth of the mandible was registered in 2 (9.5%) patients, which resulted in a relapse of mesial occlusion requiring surgical correction of the anomaly to be performed. However, the values of SNA and cm-sn-pg angles of the maxilla size in these patients indicated normal development of maxilla and midface.

The analysis of indices indicating changes in the facial skeleton due to the orthopedic effect on the maxilla was performed in the comparison

group (Table 2), where the facial mask for orthopedic treatment was used. This analysis showed that using a facial mask to treat teenagers with retro- and micrognathia results in ongoing changes of the maxilla dental arch. In particular, an increase in the inclination of the upper incisors forward is recorded (the average value of the ILS/NL angle was 124.67 ± 2.34), and improvement of the skeletal convexity improved (the average value of the angle gl-sn-pg was 176.43 ± 1.23). These changes have a positive impact on facial soft tissue profile. However, skeletal changes indicate statistically significant differences in the comparison group compared to the mean values and indicators in the experimental group.

After treatment, the SNA angle was below the reference values in both groups, although its values were closer to the average norm value in the experimental group. The ANB angle in the comparison group was sharply negative (-3.95 ± 2.74), that is, skeletal disorders remained, and its value in the experimental group was noticeably close to the average norm. In the group where the facemask therapy was applied, the maxilla (Co-A) length was 1.43 mm less than in the group with a permanent apparatus with a palatal expanding screw. The number of the “Wits,” that is, the index of skeletal disproportions, significantly exceeded the index of jaw harmony ratio (6.74 ± 0.83 mm) in the group of patients who used a face mask. In contrast, in the experimental group, it was close to the upper norm value.

Discussion

After orthopedic treatment in the experimental group, where a permanent apparatus with a palatine expanding screw was applied as per the technique described above, the position and size of the upper jaw, as well as jaw size ratios, became better, the “Wits” number has normalized. The indicators of the convex facial and nasolabial angles have improved, according to cephalometric parameters. Thus, the applied method allows for normalization of the maxilla growth and

Table 2: Comparison of cephalometric data of patients after the upper retro- and micrognathia correction by a permanent device with a palatal expanding screw and a facemask therapy

Indicator	Mean value	Apparatus with expansion screw	Face mask	Values comparison	p
SNA	82 ± 2	77.42 ± 1.95	75.83 ± 1.38	1.59 ± 0.47	<0.05
SNB	80 ± 2	80.87 ± 2.76	82.56 ± 1.76	1.69 ± 0.56	<0.05
ANB	2 ± 2	-1.34 ± 0.78	-3.95 ± 2.74	-2.61 ± 0.38	<0.05
Overbite	1-3 mm	-0.65 ± 0.34	-0.64 ± 0.42	0.01 ± 0.04	>0.05
Overjet	1-1.5 mm	1.12 ± 0.76	-0.63 ± 0.45	1.75 ± 2.34	>0.05
Co-A	-	79.77 ± 3.03	78.34 ± 3.57	1.43 ± 0.33	
Co-Gn	-	115.93.12	126.38 ± 3.96	10.45 ± 1.03	
ANS-Me	-	61.43 ± 3.48	67.48 ± 2.14	0.05 ± 0.13	
ILS/NL	115 ± 5	118.03 ± 2.87	124.67 ± 2.34	6.64 ± 1.14	<0.05
ILI/ML	90 ± 5	82.28 ± 2.74	76.75 ± 1.97	5.53 ± 1.21	<0.05
ILS/ILi	125 ± 5	132.14 ± 4.03	143.65 ± 2.84	11.51 ± 2.04	<0.05
gl-sn-pg	168 ± 5	168.96 ± 15.14	176.43 ± 1.23	7.47 ± 2.47	<0.05
cm-sn-pg	105 ± 10	110.25 ± 3.65	101.94 ± 1.44	8.31 ± 2.85	<0.05
Wits	0-4 mm	4.27 ± 1.65	6.74 ± 0.83	2.47 ± 1.52	<0.05

*SNA: Sella-Nasion to Subspinal Point Angle, SNB: Sella-Nasion to Supramental Point Angle, ANB: Subspinal Point to Supramental Point Angle, Co-A: Line condylyon to Subspinal Point, Co-Gn: Line condylyon to gnathion, ILS/NL: Axis of upper incisor to Nasal line Angle, ILI/ML: Axis of lower incisor to Mandibular line Angle, ILS/ILi: Axis of upper incisor to Axis of lower incisor Angle, gl-sn-pg: Angle of facial convexity, cm-sn-pg – Nasolabial Angle.

development in 12–14-year-old adolescents with a medium severity degree of studied pathology.

Analysis of the treatment results in patients of the comparison group shows that the face mask method does not produce significant skeletal changes in teenagers of 12–14 years. The improvement of the profile is more related to the change of incisor position rather than jaws. The indices characterizing skeletal changes after using the face mask differ significantly from those of the average normal and those after using the proposed method of orthopedic treatment. The skeletal disproportion index (the “Wits” number) showed quasi-normal values after treatment with the abovementioned method. However, it significantly surpassed the jaw harmonic ratio index in patients who used the face mask.

The treatment method using a permanent device with a palatal expanding screw showed better results than the method with a face mask. More pronounced changes of the general growth vector of the facial skeleton toward normalization of the maxilla development were noted. The anteroposterior relationship between the jaw bases normalized. The normal position of the upper and lower incisors was achieved, and a stable interincisal angle was formed. At that, the esthetics of the facial profile significantly improved. Besides, installing a permanent device with a palatal expanding screw does not require any extraoral structures, which are often poorly received by children. Furthermore, the treatment period was shorter.

The choice of methods and tactics for orthopedic treatment of patients with gnathic (skeletal) forms of mesial occlusion, in which skeletal growth is not completed, is one of the most difficult problems in modern orthodontic practice [25], [26], [27]. The necessity of early treatment in these patients is obvious, but it is difficult to predict the success of orthopedic treatment when jaw growth continues [28], [29]. Usually, these patients are advised to start treatment when the maxilla growth is complete, and all permanent teeth have erupted, that is, by 15–16 years [26]. In this case, however, the size of the maxilla is impossible to change without surgery. Besides, patients often have a formed severe bite abnormality by this age, and

they experience visible functional, morphological, and aesthetic problems. These patients undergo orthodontic and surgical treatment on the maxilla and mandible.

However, unlike the maxilla, the growth of the lower jaw lasts until 18–25 years and is genetically determined [27]. It enables the non-surgical orthopedic treatment in children with mesial occlusion and incomplete skeletal growth. Since the growth of the mandible is genetically determined and cannot be changed by orthodontic methods, the treatment should be based on stimulation of the maxilla growth (protraction) and/or correction of the mandible growth vector. The main task is to find the most effective method of orthopedic treatment for adolescents with this pathology in which the maxilla is released from the mandible, and its growth (protrusion) is stimulated.

The proposed method of orthopedic treatment is designed for patients aged 12–14 years, given the peculiarities of the dental-maxillary apparatus development at this age, imposing certain study limitations. An amendment to the method is required for patients of other ages. When choosing the method of orthodontic treatment for patients aged 12–14, it is recommended to determine the severity of mesial occlusion. Thus, the dentoalveolar compensation method is suitable for mild degree cases, and the orthopedic method affecting the maxilla development – for medium degree cases. The treatment of severe forms requires alignment of the maxilla teeth without correcting the occlusion, followed by orthognathic surgery after the age of 18 years.

Conclusion

The method proposed in this study, assuming a permanent device with a palatal expanding screw, has significantly improved patients' morphological, physiological, and esthetic performance. Evaluation of late results (4–6 years) showed normal development of the dentistry system in 90.5% of cases, which allowed avoiding surgical intervention in these patients after skeletal growth.

Clinical significance

The method proposed in this study, assuming a permanent device with a palatal expanding screw, has significantly improved patients' morphological, physiological, and aesthetic performance. Evaluation of late results (4–6 years) showed normal development of the dentistry system in 90.5% of cases, which allowed avoiding surgical intervention in these patients after skeletal growth.

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