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A MODIFIED METHOD FOR RAPID PALATAL EXPANSION ANCHORED ON MINI-IMPLANTS

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ABSTRACT — In modern orthodontic practice, a narrow upper jaw is often corrected using teeth-anchored expanders. As a result of skeletal expansion, dental orthodontic appliances have an adverse effect both on the teeth and on the supporting tissues. An analysis of the issues associated with dental fixation devices, as well as the results of combined orthodontic & surgical treatment with Surgically Assisted Rapid Palatal Expansion (SARPE), has allowed us to develop a palatal expander anchored on mini-implants. This method has been tested through the upper jaw expansion in patients in their post-pubertal period. The article offers a view at the changes in the skeletal and dental parameters during rapid maxillary expansion with the proposed expander. Skeletal expansion of the upper dentition in this case is achieved with minor changes in the lateral teeth inclination, thus allowing to minimize the risk of side effects typical for teeth-anchored expanders: root resorption, alveolar bone buccal thickness reduction, marginal bone reduction, and gum recession. The method proposed for upper jaw skeletal narrowing treatment with a palatal expander supported by mini-implants improves the upper airway.

KEYWORDS — orthodontics, upper jaw rapid expansion, expander with bone fixation, mini-implants, micro-osteoperforation, upper respiratory tract.

INTRODUCTION

Elimination of the upper jaw skeletal narrowing is one of the most complicated issues faced by practicing orthodontists. The diagnosis of *narrowing upper and lower jaw dentition* is one of the most common in daily orthodontic practice, while the prevalence of mesial occlusion within the structure of dental anomalies reaches 8–16% [1]. The upper jaw transversal plane narrowing is quite widespread — 8–23% among children and adolescents, and under 10% among adults. This anomaly is not subject to self-regulation through age [2–5].

The high need for combined treatment through puberty and at the end of the skeletal growth is due to the patient's underestimation of the role played by timely modification of the jaw and maxillofacial region soft tissue growth. Scientific literature presents contradictory data on the validity and possible relapse associated with combined treatment of the upper jaw narrowing, given the change dynamics in the position of the teeth, the tongue, the head, the temporomandibular joint heads, the respiratory tract size, the soft palate uvula [6–11]. The authors prove in this article that a <37% narrowing of the upper jaw apical base, and a >5 mm narrowing of the dental alveolar arch will take opening the interdigital suture through non-removable expanding orthodontic devices, while palatal dilators with intraosseous support would lead to a more significant effect of the lateral teeth body movement thus contributing to relapse prevention [12].

Patients whose physical growth is still underway are treated with orthodontic appliances anchored on teeth. However, there is bone suture calcification and interdigitation occurring over age. Given that, the device counteracts the anatomical resistance from the mid-palatal suture, the alveolar-zygomatic counterforce [13, 14]. SARPE (Surgically Assisted Rapid Palatal Expansion), therefore, offers an option to be used in such cases. Lately, an alternative to this method of treatment has been employed — a modified method of Miniscrew Assisted Rapid Palatal Expansion (MARPE), which is a way to expand the upper jaw with no major osteotomy, and which allows arriving at orthopedic changes affecting the middle third of the face in patients in their post-puberty period. This method allows minimizing such unfavorable effects as the lateral teeth inclination, the root and bone tissue resorption, the gum recession, reduced buccal bone thickness, and loss of the marginal bone. This is also the main feature, as well as an advantage over devices with teeth fixation [15–17].

The upper jaw deficient bone tissue often entails serious effects, one of them being a decrease in the

nasal cavity volume, which leads to obstructive sleep apnea syndrome [18, 19]. As a result, a narrow and high palate is shaped, along with a curved septum and deformed bottom of the nasal cavity, which together disturb respiratory function [20, 21].

Aim of study:

to increase the effectiveness of combined orthodontic & surgical treatment offered to patients with narrowed upper jaws using a modified palatal expander with on-bone fixation.

MATERIALS AND METHODS

The study involved 5 patients of both sexes (3 males and 2 females) with severe narrowed upper jaws and anomalies affecting the position of certain teeth (Fig. 1).

Fig. 1. *Tooth position disturbance and upper jaw narrowing*

The degree of narrowing was identified based on Pont's Index diagnostic models. The patients' age fell within the range of 14–16. For cases involving the upper jaw expansion, a palatal plate device with a screw was proposed, which was tailor-made following the palate topography (Fig. 2).

The device was fixed on the heads of orthodontic mini-implants with composite material, while 4 mini-implants (diameter — 1.5 mm; length — 6–8 mm) are included in the design as supports. When removing the screw, the device, given the bilateral skeletal support, transmits pressure to the bone tissue. The installation of mini-implants was carried out in an outpatient setting, under bilateral infiltration anesthetic (articaine anesthetics with vasoconstrictors, since the installation area features a good blood supply) at the large palatal and incisor openings, as well as in the transitional fold on the vestibular side. The correct

Fig. 2. *Palatal plate device with a screw*

positioning of the mini-implants was ensured through a surgical template (Fig. 3).

Fig. 3. *Mini-implant installation with a 3D template*

To reduce the anatomical resistance at the mid-palatal suture and the alveolar-zygomatic counterforce, micro-osteoperforations were made with a 1-mm-diameter drill. 6-mm-long mini-implants were installed in the T-zone [22], whereas 8-mm-long ones — on the palatal surface of the alveolar process between the second premolar and the first molar, on both sides (Fig. 4).

The device is activated by unwinding the screw up until complete immobility. Further activation of the device was done according to the following procedure — three activations per day for a quarter turn of the screw. This scheme of the upper jaw skeletal expansion by bone-supported devices is optimal. This protocol

Fig. 4. Appliance fixed on mini-implants

is believed to stimulate the adaptation process in the nasal-maxillary complex, reducing the risk of relapse through post-retention. The median palatal suture opening occurred on Days 14–21. Activation was carried out prior to the cross-bite removal. After the activation was completed, the devices were kept for 6 months as retentions. On the day the devices were installed, all patients were prescribed nonsteroidal anti-inflammatory drugs and rinsing with antiseptic solutions. The expander localization at the palate vault leads to a short-term alteration involving speech, as well as difficulty when eating solid food. Adjustment takes a few days. Patients with a significant thickness of the submucosal layer of the palate had the hemostatic drug Dicynone® prescribed to prevent bleeding (250 mg, 2 times a day, oral intake).

The narrowing degree was identified based on diagnostic models subject to Pont's Index. The patients' age ranged from 14 to 16. The expansion dynamics was evaluated relying on the CBCT data before, and after, applying the Yonsei Transverse Index (YTI) calculation method (Fig. 5).

The skeletal expansion values were measured by CBCT between the first premolars (P1) and the first molars (M1) in all patients for each pair of teeth.

Changed inclination of teeth was, too, calculated by the patients' CBCT data. The inclination angles of the premolars and the first molars to the sagittal plane, before and straight after the expansion, were identified. For this purpose, lines were drawn through the buccal tubercles and the root tip (mesial-buccal for the molars; buccal for the first premolars). The measurement difference showed a change in the inclination through treatment.

The alveoli vestibular plate thickness was checked on the CBCT coronal sections in the center of the examined teeth roots. The thickness was measured 4 mm apical of the enamel-cement border (Fig. 6).

The level of the marginal bone was measured on the CBCT coronal sections in the center of the examined teeth crowns. The level was measured from the top of the tooth buccal tubercle to the available level of the marginal bone in the center of the tooth root (Fig. 7).

The patients within the study underwent a 4-week clinical observation, whereas the results of the expansion were assessed relying on the patients' CBCT data, prior to, and following the appliance activation. The statistical processing was carried out with the Statistica 6.0 and Microsoft Excel 2000 software packages. The Student's t-test and a two-sample t-test with the same dispersion, were used, while the qualitative parameters were analyzed following Pearson's χ^2 criterion. The quantitative indicators are presented as an average value ± standard error (M ± m). The differences between the parameters under examination were admitted as significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

In all cases, sufficient expansion of the upper jaw was achieved in patients with no complete upper jaw osteotomy. When applying the method to all the cases, there was a diastema observed (Fig. 8).

Table 1 offers a view at the results of the maxillary skeletal expansion in the patients, taking into account the YTI.

The seam opens up in a pyramidal shape, with a wide base in the nasal direction. The analysis of the CBCT data before and after the treatment showed revealed the median palatal suture opening, which had a positive effect in terms of eliminating occlusion anomalies in the transversal plane. The resulting expansion along the alveolar arch reached 6.2–10.4 mm at the first premolars, and 5.6–9.6 mm — at the first molars. Through the entire course of treatment, two patients complained of soreness and discomfort at the hard palate during the first week. An examination showed that the mucous membrane in the area of the installed mini-implants was of pale pink coloring, with no pathological changes. There was no change observed in the periodontium and alveoli.

The course of treatment also involves the dentition expansion, which is associated with the buccal inclination of the lateral teeth. The assessment of the changes in the upper jaw lateral teeth inclination was performed on CBCT sections. The teeth inclination angles towards the sagittal plane were measured before the treatment and immediately after upper jaw active

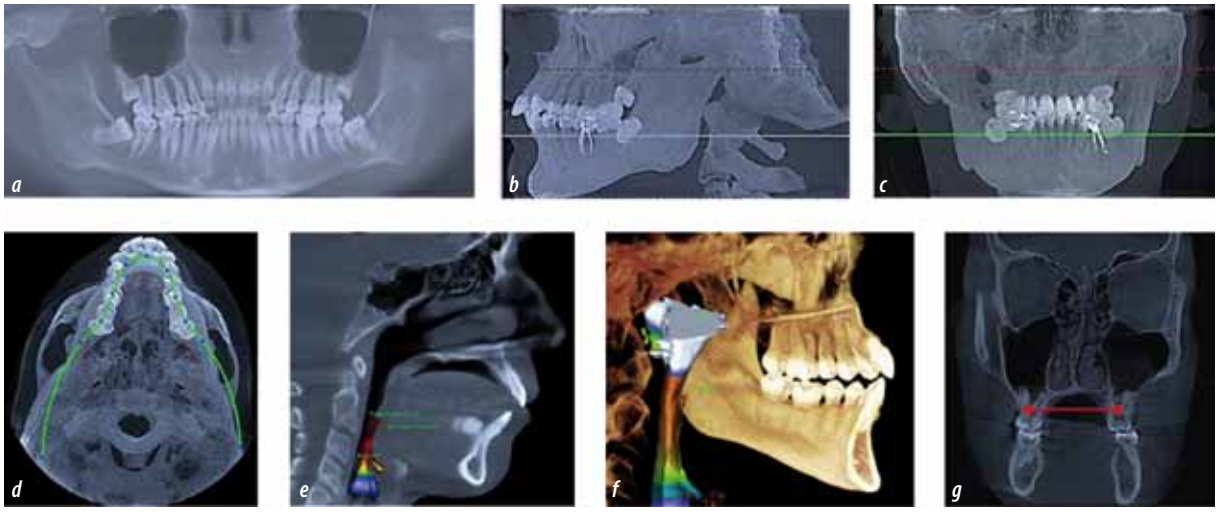

Fig. 5. Cone-beam computed tomography; patient A., 16 y.o., with the upper jaw skeletal narrowing: a, b, c — panoramic reconstruction; d — axial projection; e, f — sagittal projection with the airways volume analysis; g — frontal projection with marks for YTI identification

Fig. 6. The boundaries of identifying the alveoli vestibular plate thickness

Fig. 7. The boundaries of identifying the alveoli marginal bone thickness

Fig. 8. The skeletal expansion effect after 3 weeks

Table 1. Dynamics of the upper dentition width increase before and after active expansion, in view of the YTI, (mm)

Patient	Maxilla, CR width 16–26 pretreatment / post treatment	Maxilla width difference. CR 16–CR 26	Maxilla, CR width 14–24 pretreatment / post treatment	Maxilla width difference. CR 14–CR 24
Patient 1, girl, 14 years old	34,2/40,9	6,7	27,0/34,2	6,2
Patient 2, girl, 15 years old	35,1/40,7	5,6	28,2/35,2	7,0
Patient 3, man, 15 years old	39,3/46,8	7,5	30,1/38,2	8,1
Patient 4, man, 15 years old	36,5/45,1	9,6	23,3/33,7	10,4
Patient 5, man, 16 years old	38,4/47,9	9,5	29,0/38,1	9,1

expansion was completed. Table 2 shows the change in the teeth inclination.

Using a palatal expander with a fixation on bones ensures the dentition expansion, which is due to expanding the upper jaw skeleton, while the change in the dental component size is insignificant. A change in the teeth inclination during the expansion is obvious, however, and is caused by the out-

Table 2. *The lateral teeth inclination angle change in patients after completing the active expansion of the upper jaw (M = m), (°), (p≤0.05)*

Tooth topography	Change options:
P1 (14) Rincl	3,08 ± 0,49
M1 (16) Rincl	3,91 ± 1,47
P1 (24) Lincl	1,07 ± 0,23
M1 (26) Lincl	2,59 ± 0,54

ward movement (bending) of the alveolar processes themselves.

Rapid expansion may also be accompanied with some changes involving the periodontal tissues of the upper jaw lateral teeth, which reveals itself through resorption of the alveolar process bone. Table 3 shows the measurements of the vestibular plate thickness in the alveolar process at the examined teeth.

Table 3. *Thickness parameters of the alveolar process vestibular plate before and after active expansion (M±m), (mm), (p≤0.05)*

Tooth topography	Dimensional quantities:	
	Before treatment	After active expansion
P1 (14,24) buccal	0,78 ± 0,07	0,78 ± 0,09
M1 (16,26) buccal	2,06 ± 0,37	1,89 ± 0,26

Following the evaluation of the treatment with a palatal bone-fixed expander, there were no statistically significant changes found in the thickness of the alveolar process vestibular plate.

The marginal bone level measurements at the examined teeth can be seen in Table 4.

Table 4. *Marginal bone thickness before and after active expansion (M=m), (m), (p≤0.05)*

Tooth topography	Dimensional quantities:	
	Before treatment	After active expansion
P1 (14,24) buccal	9,78 ± 0,27	9,91 ± 0,22
M1 (16,26) buccal	8,06 ± 0,34	8,43 ± 0,41

The assessment of the treatment with a palatal expander involving bone fixation, revealed no statistically significant changes in the marginal bone level.

The devices relying on bone support, therefore, allow the upper jaw expansion while keeping the tooth supporting tissues almost unchanged.

Figure 9 shows the assessment results for the upper jaw skeletal expansion using a palatal expander with bone fixation, combined with micro-osteoperforation, in patients with the upper jaw narrowing based on CBCT data.

Further orthodontic treatment using braces allowed improving the dentition occlusion, ensuring multiple fissure-tubercle contacts, restoring the face symmetry and proportion, improving the middle face area volume, normalizing the incisional lines of the dental arches, eliminating palatal occlusion and dysocclusion in the vertical and sagittal directions, improving certain teeth position, and eliminating the discrepancy in the dental arch size of the upper and the lower jaw (Fig. 10).

Subjectively, all patients reported relieved breathing. This could be attributed to an increase in the nasal cavity width. MARPE may have increased the airway (the short-term observation data). One patient's parents reported significantly improved sleep with improved respiratory function and no longer observed snoring. Respiratory tests and rhinopneumometry in patients before and after the maxillary dilation revealed an improvement in the upper respiratory tract capacity (40% to 53%; Fig. 11), proof to that being the data to be found in respective scientific literature [23].

CONCLUSION

1. Miniscrew Assisted Rapid Palatal Expansion (MARPE), when combined with micro-osteoperforation, is mainly a consequence of the upper jaw skeletal expansion with minimal effect from the dental component. The buccal inclination of the lateral teeth, which occurs during the expansion, is insignificant.

2. The change in the lateral teeth inclination is mainly due to the outward (vestibular) bending of the alveolar processes.

3. The advantage of upper jaw dental alveolar arch intensive expansion with respective devices fixed on bones (MARPE), as well as of the developed protocol, if compared with Surgically Assisted Rapid Palatal Expansion (SARPE), is its lower invasiveness, as well as potential to be used both during the bite replacement in adolescents, and when dealing with adult patients featuring a completely shaped bite.

4. A palatal expander with bone fixation, if used for the upper mandible rapid expansion in orthodontic practice, will help avoid such undesirable changes affecting teeth and their supporting tissues as root resorption, reduced buccal bone thickness, loss of marginal bone, and gum recession, observed typically in case of using expanders relying on teeth.

5. There is a need for improving the treatment algorithm, based on respective analysis of clinical and

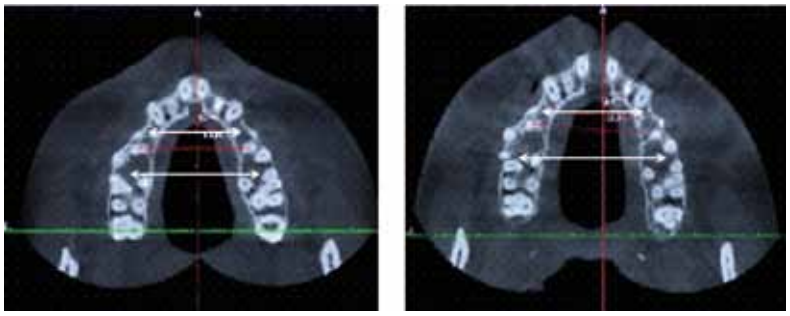

Fig. 9. Computed tomogram, patient A., 16 y.o., with upper jaw severe narrowing before (a) and after (b) using a palatal expander with bone fixation.

Fig. 10. Virtual diagnostic Set-Up model (ORAPIX 3Txer 2.5.0 file (Japan); patient A., 16 y.o., with the upper jaw severe narrowing before (a) and after (b) combined orthodontic & surgical treatment

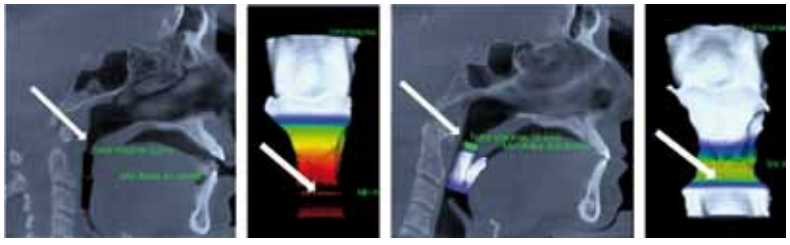

Fig. 11. Increased volume of the respiratory tract (CBCT data) before (a, b) and after (c, d) combined orthodontic & surgical treatment

radiological data, depending on the median palatal suture ossification, the bone biotype, the degree of the upper jaw narrowing, and the lateral teeth inclination, which, in turn, will allow arriving at both functional and aesthetically qualitative outcome of combined orthodontic & surgical treatment.

6. In case of combined orthodontic & surgical treatment used to treat patients with the upper jaw narrowing, there is an expansion of the middle face and an improved respiratory function of the nose. Further studies in this area, involving a larger pool of patients, would allow substantiating the clinical effectiveness of this method when treating obstructive sleep apnea.

7. Upon activating the device, there is a recommendation to carry out additional research methods (CBCT, X-ray of the hard palate, teleroentgenography in direct projection) to assess the maxillary expansion. Physiological regeneration of bone tissue following the upper jaw expansion, a bone supported palatal expander is recommended to be kept as a retention device for at least 6 months.

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