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Short-term sagittal changes of the upper and lower jaws in patients treated with acrylic-splint rapid palatal expander before growth peak

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Rapid palatal expansion can determine an improvement of the sagittal relationship between maxilla and mandible. The purpose of this study was to evaluate the skeletal and dentoalveolar effects of the upper and lower jaws on the sagittal plane in subjects treated with acrylic-splint rapid palatal expander before growth peak. 36 patients aged 6-10 years with a cervical vertebral maturation stage of CS1 or CS2 were selected. Skeletal and dentoalveolar variables on the cephalometric traces of the lateral teleradiographs were measured before (T0) and at the end (T1) of the orthodontic treatment. The same variables were measured in a subgroup (20 subjects) of the same sample, characterized by a skeletal Class II malocclusion (ANB ≥ 4°) at T0. Statistics used was paired samples t-test. The p-value was considered statistically significant for P<0.05. In the whole sample ANB showed a significant decrease (-0.96±1.75°). Pg-OLp and Co-OLp + Pg-OLp increased of 4.25±6.07 mm and 4.89±6.65 mm respectively. FMA angle showed a significant decrease (-1.26±2.47°). In the subgroup with skeletal Class II malocclusion the results were similar, but it was also registered a significant increase of SNB (1.37±2.14°). In addition to the correction of the cross-bite, the treatment with acrylic-splint rapid palatal expander determined an improvement of the dento-basal discrepancy in the maxilla, an improvement of the skeletal maxillo-mandibular relationships, an anterior repositioning and length increase of the mandible and a facial height reduction.

The rapid palatal expansion has acquired a role of primary importance in modern orthodontics as a safe, predictable and effective method to correct the transverse maxillary deficit (1). In addition to an increase of the transverse diameter of the palatal vault and the correction of the cross-bite, there are many data in the literature regarding the favorable effects of this therapy in increasing the amplitude of the nasal cavities and the length of the upper arch perimeter (2-19). Concerning the effects of the rapid palatal expansion on the sagittal plane, the opinions presented in the literature appear conflicting. Some Authors reported a forward and downward repositioning of the maxilla after rapid palatal expansion (20-23). Cleall et al. considered that the maxilla gets back to its original position during retention (24). Other Authors observed that the forward and downward displacement of the maxilla can be minimized by using a type of expander with acrylic occlusal splints (25). Other studies reported a spontaneous anterior repositioning of the mandible after rapid palatal expansion in patients with Class II malocclusion due to mandible retrusion (26-29). The aim of this study was to evaluate the skeletal and dentoalveolar effects at the level of upper and

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lower jaws on the sagittal plane in subjects treated with acrylic-splint rapid palatal expander before growth peak.

MATERIALS AND METHODS

In this study 36 subjects (18 males and 18 females) aged between 6 and 10 years were selected. At the beginning of the treatment (T0) the patients were in mixed dentition and their mean age was 8.11±2.3 years. The inclusion criteria were: skeletal transverse deficit of the maxilla; monolateral or bilateral skeletal cross-bite; CS1 or CS2 cervical vertebral maturation stage according to Baccetti et al. (30). The exclusion criteria were: genetic or endocrine diseases that could affect the treatment plan; previous orthopaedic and/or orthodontic treatment; skeletal abnormalities or significant facial asymmetry (19,31-36). The transverse discrepancy of the patients was measured on the dental casts using a caliper with 0.01 mm accuracy to quantify the needed expansion. Since all subjects had a mixed dentition, the transverse discrepancy was the result of the difference between the superior intermolar distance (distance between the central fossae of the upper first permanent molars) and the inferior intermolar distance (distance between the top of the disto-buccal cusps of the inferior first permanent molars). All subjects had an initial upper arch width inferior to 30 mm. The patients were treated with acrylic-splint rapid palatal expander (i.e. McNamara-type rapid palatal expander): it was composed of Hyrax-type screw embedded into a wire-and-acrylic framework; the acrylic splints were bonded to the deciduous molars and the permanent first molars (37-38). The patients' parents were instructed to activate the expansion screw twice a day until the palatal cusps of the maxillary posterior teeth approximated the buccal cusps of the mandibular posterior teeth: every activation was a 0.25 mm expansion. Once reached the correct expansion, the screw was blocked and the expander was kept in place for six months: this period was necessary to allow the reorganization of the midpalatal suture. At the end of this period (T1), the expander was removed, cleaned and given to the patient to wear it as retainer at night for further 6 months. If the expander was not sufficiently retentive, the patient wore a Hawley retainer (39). At the end of the orthodontic treatment skeletal and dentoalveolar variables on the cephalometric traces of the initial (T0) and final (T1) lateral teleradiographs were measured with Dolphin Imaging 11.7 software (Dolphin, Imaging & Management Solutions, Chatsworth, CA, USA). Parameters derived from Steiner, Tweed, Ricketts, Pancherz and Bjork cephalometric analyses were measured in order to gather all the measurement variables often used in the literature (Table I) (40).

Table I. *Skeletal and dentoalveolar variables.*

Variable	Description
SNA	Antero-posterior positioning of maxilla in relation to cranial base
SNB	Antero-posterior positioning of mandible in relation to cranial base
ANB	Relative position of the maxilla to mandible
A-OLp	Position of the maxillary base
Pg-OLp	Position of the mandibular base
Co-OLp	Position of the condylar head
Pg-OLp + Co-OLp	Sagittal mandibular lenght
Co-Gn	Total mandibular lenght
Co-A	Maxillary length
FMA	Frankfort-Mandibular plane Angle
U1-OL	Inclination of upper incisor
L1-OL	Inclination of lower incisor
U1-L1	Interincisal angle
is/OLp - ii/OLp	Overjet
ms/OLp - mi/OLp	Molar relation
U1-SN	Inclination of maxillary incisor to anterior cranial base
IMPA (L1-MP)	Incisor Mandibular Plane Angle
FMIA (L1-FH)	Frankfort-Mandibular Incisor Angle

This study was approved by the Clinical Investigation Ethics Committee of Verona and Rovigo, Italy (protocol number 70252). The statistical analysis was performed using the software STATA (version 13; StataCorp LP, College Station, Texas, USA). Mean and standard deviation (SD) were calculated for all cephalometric variables at T0 (pre-treatment) and at T1 (after treatment). Paired samples t test was performed for the evaluation of the skeletal and dentoalveolar changes that occurred during treatment with rapid palatal expander. The p-value was considered statistically significant if less than 0.05. The same evaluation was performed for a subgroup (20 subjects) of the same sample, characterized by a skeletal Class II malocclusion (ANB ≥ 4°) at T0.

RESULTS

The results of the changes of the skeletal variables at T0 and T1 are reported in Table II.

SNA and SNB showed no statistically significant differences between T0 and T1. ANB underwent a statistically significant decrease between T0 and T1 (-0.96±1.75°, P<0.05), indicating an improvement of the sagittal relationships between the maxilla and the mandible. Pancherz analysis was adopted to assess the positions of the maxilla, the condylar head and the mandible and the length of the mandible on the sagittal plane. No statistically significant differences were found for A-OLp (1.93±5.23 mm, P>0.05) and Co-OLp (0.61±2.50, P>0.05). Pg-OLp showed a statistically significant increase (4.25±6.07 mm, P<0.05), suggesting an advancement of the mandibular position. As regards the total mandibular length, measured as Co-OLp + Pg-OLp, a statistically significant increase (4.89±6.65mm, P<0.05) was found. FMA angle showed a statistically significant decrease between T0 and T1 (-1.26±2.47mm, P>0.05), indicating a horizontally mandibular advancement rather than a vertical one. The results regarding the changes of the dentoalveolar variables at T0 and T1 are reported in Table III.

Only the variables related to the inclination of the upper incisors showed statistically significant changes: in particular, there was a proclination of the upper incisors given by the decrease of U1-OL angle (-2.55±3.39°, P <0.05) and by the increase of U1-SN angle (3.12±4.07°, P<0.05). The results regarding the changes of the skeletal and dentoalveolar variables at T0 and T1 in the subgroup of Class II malocclusion patients are reported in Table IV.

With regard to the sagittal position of the maxilla, SNA and A-OLp did not show statistically significant differences between T0 and T1. The sagittal mandibular position was evaluated by analysing SNB and Pg-OLp. As regards the comparison between the values of Pg-OLp at T0 and T1, a statistically

Table II. *Changes of the pre- (T0) and post-treatment (T1) skeletal variables.*

Skeletal variables	T0	T1	T1-T0	P-value (P)	Significant (S) / Not Significant (NS)
SNA (°)	81.18 ± 4.04	81.19 ± 3.87	0.02 ± 1.47	0.9622	NS
SNB (°)	77.35 ± 3.51	78.29 ± 3.41	0.94 ± 2.03	0.0661	NS
ANB (°)	3.86 ± 2.14	2.89 ± 2.33	- 0.96 ± 1.75	0.0325	S
A-OLP (mm)	73.38 ± 6.48	75.31 ± 5.23	1.93 ± 5.23	0.1355	NS
Pg-OLP (mm)	80.11 ± 8.58	84.36 ± 7.15	4.25 ± 6.07	0.0086	S
Co-OLP (mm)	4.01 ± 3.98	4.61 ± 2.37	0.61 ± 2.50	0.3191	NS
Pg-OLP + Co-OLP (mm)	84.1 ± 8.17	88.99 ± 7.42	4.89 ± 6.65	0.0062	S
Co-Gn (mm)	98.26 ± 8.74	103.32 ± 9.69	5.06 ± 8.90	0.0274	S
Co-A (mm)	77.51 ± 6.60	80.12 ± 5.44	2.61 ± 6.23	0.0941	NS
FMA (°)	26.28 ± 3.10	25.03 ± 3.41	- 1.26 ± 2.47	0.0453	S

Table III. *Changes of the pre- (T0) and post-treatment (T1) dentoalveolar variables.*

Dentoalveolar variables	T0	T1	T1-T0	P-value (P)	Significant (S) / Not Significant (NS)
U1-OL (°)	58.1 ± 43.65	55.59 ± 3.07	- 2.55 ± 3.39	0.0054	S
L1-OL (°)	71.98 ± 5.61	70.71 ± 5.11	- 1.27 ± 3.87	0.1807	NS
U1-L1 (°)	130.12 ± 7.77	126.28 ± 6.28	- 3.84 ± 3.41	0.0002	S
is/OLP-ii/OLP (mm)	3.68 ± 2.36	3.683 ± 2.68	0.006 ± 1.57	0.9882	NS
ms/OLP-mi/OLP (mm)	- 0.43 ± 1.7	- 1.23 ± 1.85	- 0.8 ± 1.71	0.0629	NS
U1-SN (°)	103.84 ± 5.57	106.96 ± 5.05	3.12 ± 4.07	0.0046	S
IMPA (L1-MP) (°)	91.81 ± 6.14	93.29 ± 5.26	1.49 ± 3.62	0.0993	NS
FMIA (L1-FH) (°)	61.93 ± 5.65	61.67 ± 5.02	- 0.27 ± 4.50	0.8046	NS

The values are expressed as mean±standard deviation (SD) and their difference. It is also reported the p-value and the significance obtained by the paired samples t test.

Table IV. *Changes of the pre- (T0) and post-treatment (T1) skeletal and dentoalveolar variables in the subgroup of Class II malocclusion patients.*

Skeletal and dentoalveolar variables	T0	T1	T1-T0	P-value (P)	Significant (S) / Not Significant (NS)
SNA (°)	81.61 ± 4.31	81.74 ± 3.94	- 0.2 ± 1.53	0.7634	NS
SNB (°)	76.78 ± 3.79	78.15 ± 3.79	1.37 ± 2.14	0.0401	S
ANB (°)	4.85 ± 0.99	3.58 ± 2.19	- 1.27 ± 1.63	0.0156	S
A-OLP (mm)	73.01 ± 6.43	74.50 ± 4.64	1.49 ± 4.86	0.2898	NS
Pg-OLP (mm)	78.61 ± 8.05	82.47 ± 4.52	3.85 ± 6.38	0.0499	S
Co-OLP (mm)	4.19 ± 4.52	4.61 ± 2.68	0.42 ± 2.53	0.5578	NS
Pg-OLP + Co-OLP (mm)	82.78 ± 7.94	87.11 ± 4.62	4.32 ± 6.69	0.0382	S
Co-Gn (mm)	96.28 ± 7.85	100.03 ± 5.06	3.75 ± 8.27	0.1283	NS
Co-A (mm)	77.31 ± 6.67	79.27 ± 4.61	1.95 ± 5.72	0.2419	NS
FMA (°)	26.38 ± 3.54	24.38 ± 3.01	- 2.01 ± 2.06	0.0043	S
U1-OL (°)	57.77 ± 4.19	55.49 ± 3.30	- 2.29 ± 3.79	0.0586	S
L1-OL (°)	70.48 ± 4.33	69.37 ± 4.91	- 1.11 ± 4.01	0.3388	NS
U1-L1 (°)	128.23 ± 7.17	124.92 ± 5.88	- 3.31 ± 3.70	0.0072	S
is/OLP - ii/OLP (mm)	3.81 ± 2.58	3.777 ± 3.16	- 0.039 ± 1.51	0.9285	NS
ms/OLP - mi/OLP (mm)	- 0.34 ± 1.75	- 1.22 ± 1.98	- 0.88 ± 2.01	0.1378	NS
U1-SN (°)	103.10 ± 6.12	106.31 ± 5.26	3.21 ± 4.63	0.0276	S
IMPA (L1-MP) (°)	94.05 ± 4.58	95.10 ± 4.76	1.02 ± 3.88	0.3606	NS
FMIA (L1-FH) (°)	59.58 ± 3.69	60.54 ± 5.23	0.95 ± 4.00	0.4067	NS

The values are expressed as mean±standard deviation (SD) and their difference. It is also reported the p-value and the significance obtained by the paired samples t test.

significant increase was found (3.85±6.38 mm, $P<0.05$), suggesting an advancement of the sagittal mandibular position. SNB increased of 1.37±2.14° ($P<0.05$). The maxillo-mandibular relationship was evaluated through ANB: the angle decreased of 1.27±1.63° ($P<0.05$). FMA showed a statistically significant decrease between T0 and T1 (-2.01±2.06°, $P<0.05$), indicating a mandibular advancement in the horizontal direction rather than in the vertical one. Regarding the dentoalveolar variables, the only significant change regarded the proclination of the upper incisors, as it was observed in the total sample.

DISCUSSION

No statistically significant differences were found in the sagittal position of the maxilla (expressed by SNA, A-OLp and Co-A) between T0 and T1. As these values were not significant, it can be inferred that the therapy with the acrylic-splint rapid palatal expander did not affect the maxillary growth in the antero-posterior direction. These results were in agreement with the studies conducted by Da Silva et al., Asanza et al. and Sarver et al. (25,41,42). In this latter study the Authors observed that the anterior displacement of the maxilla due to treatment with banded rapid palatal expander could be minimized through the use of an acrylic-splint rapid palatal expander: therefore, it can be an effective treatment option for patients with Class II malocclusion. Regarding the sagittal position and the length of the mandible, it was found: an increase of Pg-OLp distance, indicating an anterior displacement of the lower jaw; an increase of Pg-OLp + Co-OLp and Co-Gn, indicating an increased mandibular length. The anterior displacement of the mandible was in part due to the mandibular growth and in part to its anterior repositioning. The values representing the sagittal position of the mandible were even more expressive in the subgroup of Class II malocclusion patients. In particular, there was a statistically significant increase of SNB (1.37±2.14°, $P<0.05$) and Pg-OLp (3.85±6.37 mm, $P<0.05$) between T0 and T1. Therefore, the therapy with acrylic-splint rapid palatal expander favoured an advancement of the mandible thanks to its release from the dental occlusal contacts with the upper jaw: in this way, it led to an improvement of the maxillo-mandibular relationships. This was also confirmed by the statistically significant reduction of ANB both in the whole sample (-0.96±1.75°, $P<0.05$) as well as in the Class II subgroup (-1.27±1.63°, $P<0.05$). This suggested that the acrylic-splint rapid palatal expander can be an effective choice for the treatment of all those patients who have a transverse maxillary deficit associated with a mandibular retrusion. In the subjects with Class II malocclusion the therapy with rapid palatal expander favoured a spontaneous mandibular repositioning that led to an improvement of the maxillo-mandibular relationship. This is why it is important to perform the Frankel manoeuvre to assess the need of a palatal expansion before the orthodontic treatment in Class II malocclusion subjects with mandibular retrusion (43). This consideration, together with our results, is in agreement with a study by Guest et al, in which the sagittal effects of a group of Class II division I malocclusion subjects treated with acrylic-splint rapid palatal expander are compared with those of an untreated control group with the same malocclusion (26). These observations are also comparable to those reported by McNamara, who observed that the rapid palatal expansion led to a spontaneous growth or to an advancement of the mandible in subjects with Class II malocclusion (44-45). Regarding the effects of the rapid palatal expansion on the vertical plane, there was a statistically significant decrease of FMA (-1.26±2.47mm, $P>0.05$), indicating a facial height reduction. This might be caused by the likely intrusion of the posterior maxillary teeth, due to the action of masticatory forces on acrylic splints. This suggested that therapy with the acrylic-splint rapid palatal expander can be very favourable in hyperdivergent subjects, who present a vertical mandibular growth pattern. Our results were similar to those by De Rossi et al. and Cohen and Silverman, who affirmed that the presence of the acrylic splints could inhibit the alveolar growth and the eruption of the posterior teeth, thus becoming the ideal choice for all those patients with an increased facial height and overly inclined mandibular plane (46-47). Regarding the analysed dentoalveolar variables, only the values representing the inclination of the upper incisors and the interincisal angle showed statistically significant variations. In particular, a proclination of the upper incisors was found. This finding could be due to the presence of the resin splints which determined an anterior position of the tongue in contact with the upper incisors, causing an almost continuous force able to proclinate them.

In addition to the correction of the cross-bite, the orthodontic treatment with acrylic-splint rapid palatal expander in subjects before growth peak determined: improvement of the dento-basal discrepancy in the upper jaw; improvement of the skeletal maxillo-mandibular relationship; anterior repositioning and length increase of the mandible; facial height reduction.

This therapy appears to be effective and advantageous in all those subjects that present a Class II malocclusion with mandibular retrusion and/or hyperdivergent growth pattern.

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